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ORIGINAL ARTICLES

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EDITOR OF THE MONTH

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Cleveland, Ohio

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APPROVED SCHOOLS FOR PHYSICAL THERAPY TECHNICIANS ‡

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THE HEATING EFFECTS OF MICROWAVES WITH AND WITHOUT ISCHEMIA *§

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It has been shown recently that when living tissues are irradiated with microwaves, an increase in tissue temperature[1] and blood flow[2] results. Effects other than the rise in temperature of tissues are occupying the interest of some investigators.[3]

The purpose of this study was twofold: (1) to make a comparison of the effects of microwaves on the temperature of tissues with and without ischemia and (2) to determine if possible an optimal period of irradiation for heating tissues.

Since microwave irradiation of living tissues causes an increase in blood flow, the question arose: What would the effect be if an increase in blood flow were not possible? It was thought that exposing tissue with artificially induced ischemia to microwaves might give some indications as to what would happen when microwaves were applied to tissues with insufficient circulation which is often seen clinically. Furthermore, since microwaves are in use clinically, it is particularly important to determine the optimal period of irradiation. The optimal period was investigated by recording the temperatures produced when the duration of irradiation was varied.

Method

The source of microwave energy used in this study was a generator with a multicavity magnetron tube which produces continuous electromagnetic waves of a wavelength of about 12 cm. at an oscillating frequency of 2,450

* Read at the Twenty-Sixth Annual Session of the American Congress of Physical Medicine, Washington, D. C., Sept. 8, 1948.

§ Abridgment of thesis submitted by Dr. Worden to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Physical Medicine.

1. (*a*) Leden, Ursula M.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: Preliminary Studies on the Heating and Circulatory Effects of Micro-Waves —→ "Radar." Brit. J. Phys. Med. 10:177 (Nov.-Dec.) 1947. (*b*) Krusen, F. H.; Herrick, J. F.; Leden, Ursula, and Wakim, K. G.: Microkymatotherapy: Preliminary Report of Experimental Studies on the Heating Effect of Microwaves ("Radar") in Living Tissue, Proc. Staff Meet., Mayo Clin. 22:209 (May 28) 1947. (*c*) Kemp, C. R.; Paul, W. D., and Hines, H. M.: Studies Concerning the Effect of Deep Tissue Heat on Blood Flow, Arch. Phys. Med. 29:12 (Jan.) 1948. (*d*) Horvath, S. M.; Miller, R. N., and Hutt, B. K.: Heating of Human Muscle Tissue by Micro Waves, Federation Proc. 7:58 (Mar.) 1948. (*e*) Osborne, S. L., and Frederick J. N.: Microwave Radiations; Heating of Human and Animal Tissues by Means of High Frequency Current with Wavelength of Twelve Centimeters (the Microtherm), J. A. M. A. 137:1036 (July 17) 1948.

2. Footnote 1 a, b and c.

3. Daily, L. E.: A Clinical Study of the Results of Exposure of Laboratory Personnel to Radar and High Frequency Radio, U. S. Nav. M. Bull. 41:1052 (July) 1943. Lidman, B. I., and Cohn, Clarence: Effect of Radar Emanations on the Hematopoietic System, Air Surgeon's Bull. 2:448 (Dec.) 1945. Follis, R. H., Jr.: Studies on the Biological Effect of High Frequency Radio Waves (Radar), Am. J. Physiol. 147:281, Oct.) 1946.

megacycles per second. A type A hemispheric director[4] was used for transmitting the microwaves from the coaxial cable of the generator onto the area of the tissues under study.

Dogs weighing 12 Kg. or more were used exclusively in this investigation.

When the effects of microwave irradiation on tissues with reduced blood supply were studied, the dogs were anesthetized with sodium pentobarbital given intravenously (25 mg. per kilogram of body weight). A median abdominal incision was made for placing an adjustable screw clamp[5] (fig. 1) loosely around the aorta distal to the origin of the mesenteric artery. The incision was closed by sutures, but the handle of the clamp, containing an adjustable screw, was left extending outside the abdomen through a small gap between sutures in the incision. With this technic we were able to produce ischemia of the tissues by clamping the aorta before exposure to microwaves.

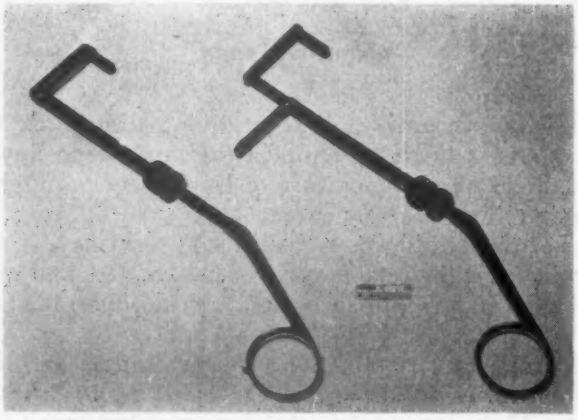

Fig. 1. — Adjustable screw clamp used to clamp the abdominal aorta when ischemia of the thigh was desired.

Skin temperatures were recorded by means of a thermistor.[6] The thermistor is a thermally sensitive resistor with a negative temperature coefficient. Ambient temperatures can be determined by measuring the actual resistance of the thermistor at any moment.

The temperatures of the subcutaneous tissue, superficial muscle and deep muscle were recorded with needle thermocouples. All observations of temperature were continuously registered galvanometrically on moving photographic film.

The hair over the thigh of the dog was clipped closely, and the outline of the heating pattern was drawn on the thigh with gentian violet (fig. 2). From the manufacturer's description of the heating pattern, the area of 100 per cent concentration of energy was carefully outlined and in that area the temperatures of the skin, subcutaneous tissues and superficial and deep muscles were recorded before and after exposure to microwaves.

The temperature of superficial muscles was taken at a depth of 1.5 cm. and that of the deep muscles at a depth of 3 cm. The output of the microwave generator was 30 watts, and the distance of the director from the skin was 2.5 cm. in all the studies.

4. Footnote 1 a and b.
5. Deterling, R. A., and Essex, H. E.: An Instrument Designed Primarily for Use in Surgical Procedures on the Aorta, Am. J. Surg., to be published.
6. Becker, J. A.; Green, C. B., and Pearson, G. L.: Properties and Uses of Thermistors — Thermally Sensitive Resistors, Electrical Engineering (Nov.) 1946. Drummeter, L. F., Jr., and Fastie, W. G.: A Simple Resistance Thermometer for Blood-Temperature Measurements, Science 105:73 (Jan. 17) 1947.

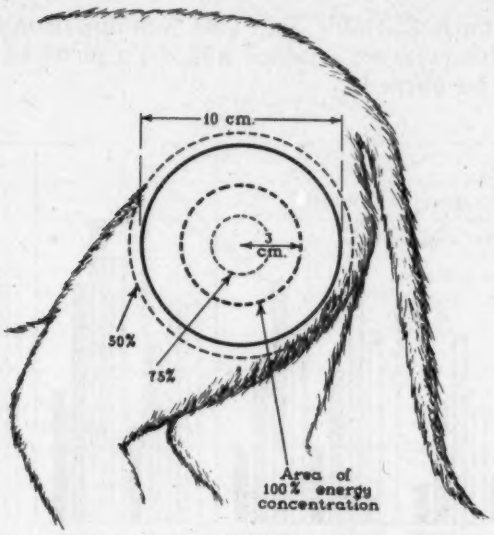

Fig. 2. — The approximate site of exposure to microwaves and the heating pattern produced by a type A hemispheric director at a distance of 2.5 cm. from the skin.

Procedure

The thigh of the fasting dog[7] was prepared as described, the thermistor was placed on the skin, the thermocouple needles were inserted into the tissues and control temperatures were established. As soon as satisfactory controls were obtained, the thermistor and thermocouples were removed from the field and the area was exposed to microwaves for a given period. Immediately after the microwave generator was turned off, the thermistor and thermocouples were replaced in their original positions and the temperatures recorded within thirty seconds after irradiation was stopped.

Results

Effects of Microwaves on Ischemic Tissues. — The average increase of temperature in ischemic tissues did not differ appreciably from those of tissues with intact circulation when the duration of exposure to microwaves was five or ten minutes (fig. 3). There was no evidence of burning after these shorter periods of exposure even though the tissues were made ischemic by clamping the aorta. After exposure to microwaves for periods of fifteen or twenty minutes, the temperature of ischemic tissues rose higher than that of tissues with intact circulation. However, the differences in temperature rise were not marked. When the tissues were made ischemic, burning occurred in 4 of the 5 animals exposed for fifteen minutes and in all 6 of those exposed for twenty minutes. In no instance did burning occur when the circulation was intact, nor was there any evidence of burning when irradiation was repeated for six consecutive periods of twenty minutes each at the same site when the circulation was intact.

After one exposure to microwaves for fifteen minutes, the highest temperature when the circulation was intact was 44.6 C., and there was no evidence of burning. After ischemic tissues were exposed to microwaves for twenty minutes, the highest temperature was only 42.3 C., yet there was

7. Herrick, J. F.; Essex, H. E.; Mann, F. C., and Baldes, E. J.: Effect of Digestion on Blood Flow in Certain Blood Vessels of Dog, Am. J. Physiol. 108:621 (June) 1934.

gross evidence of burning (table 1). This was one of many cases in which the magnitude of temperature attained was not a guide as to whether or not the tissues might be burned.

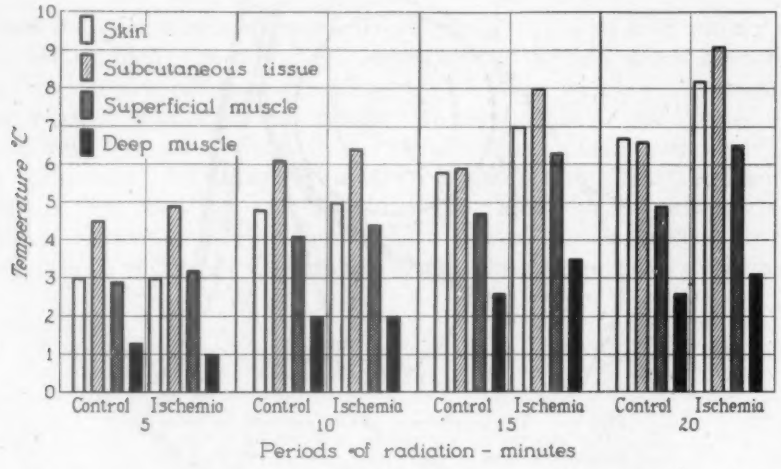

Fig. 3. — The average increase of temperature in thigh of dogs after microwave irradiation with and without ischemia in experiments performed at different periods of irradiation: 3 for five minutes, 4 for ten minutes, 5 for fifteen minutes and 6 for twenty minutes. The control is the average increase of temperature after exposure when the circulation was intact.

Table 1. — *Temperature Tolerance of Tissue: Comparison of Extremes of Heating with Microwaves in Ischemic and Nonischemic Tissues.*

Tissue	Temperature, °C. Before Radiation — Ischemia Present	Before Radiation — Ischemia Absent	After Radiation for: 20 Min.; Ischemia Present	After Radiation for: 15 Min.; Ischemia Absent
Skin	35.9	36.5	41.6	40.4
Subcutaneous tissue	35.1	36.7	42.3*	42.0
Superficial muscle	36.6	37.8	41.7	44.6*
Deep muscle	37.4	37.9	40.2	41.0
Burning present			Yes	No

* Highest temperatures.

It was concluded that the burning produced in these experiments was due not only to the increased duration of exposure but also to the loss of the protective mechanism for the dissipation of heat provided by the circulating blood.

In all cases in which burns occurred, the first evidence of burning appeared over the femur where it crossed the zone of 100 per cent concentration of energy (fig. 4). It was observed that the greater the prominence of the femur, the severer was the burn. This suggests that microwave diathermy should be used with caution in treating areas with bony prominences.

The location of blebs after exposure to microwaves for fifteen minutes with the aorta clamped is shown in figure 4. After the aorta had been released and the temperatures had returned to control levels, the area was again exposed to microwaves for fifteen minutes, after which temperatures were recorded at the original sites. After three minutes, the needles were quickly withdrawn from the subcutaneous tissue and superficial muscle and inserted into a bleb. The temperature in the bleb was much higher than that of the surrounding tissues. After three more minutes, the needles were

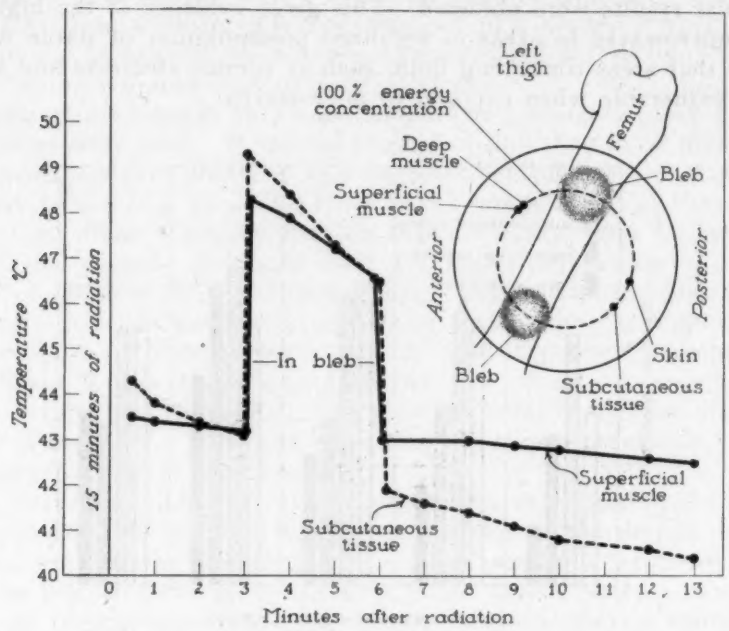

Fig. 4. — Temperature variations after microwave irradiation when blebs are present. The right upper corner shows the relationship of the heating pattern to the femur. In all cases in which burning occurred, the first evidence of burning was over the femur and at a site in which it crossed the area of 100 per cent concentration of energy. After cooling to control levels, an area of bleb formation was again exposed. After exposure the normal cooling curve is shown for the first three minutes; then the subcutaneous and superficial muscle needle thermocouples were immediately placed in the proximal bleb. A marked rise in temperature is evident. Three minutes later, the needles were replaced in their original sites, and the cooling curve was continued.

removed from the bleb and replaced in their original positions, whereupon the rate of cooling found previously in these tissues was noted again. A comparison of the temperature of the neighboring tissues with that inside the bleb was made in several experiments when bleb formation occurred,

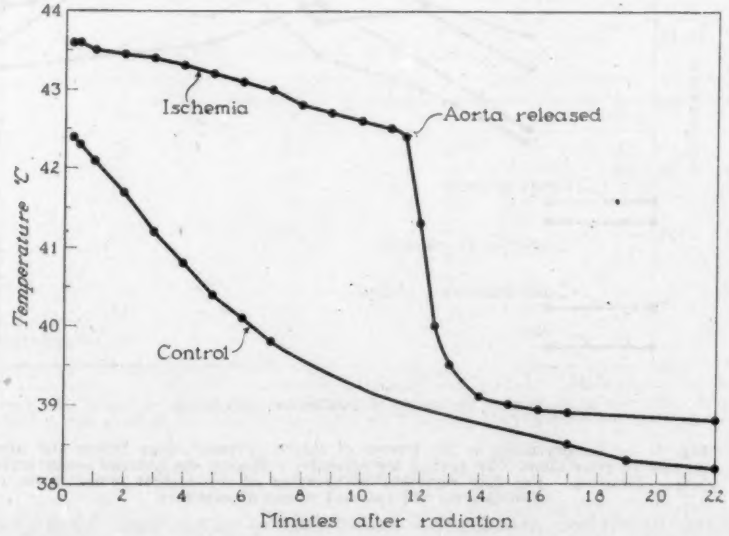

Fig. 5. — Comparison of cooling curves with and without ischemia in deep muscle after fifteen minutes of microwave irradiation. The rate of cooling of ischemic tissue was slower than normal tissue even though the temperature rise was greater. Releasing the aorta resulted in rapid cooling of ischemic tissues.

and similar results were obtained. This gives evidence of the high absorption of microwaves in areas of localized accumulation of tissue fluids and suggests that areas containing fluid, such as edema, effusions and abscesses, may be vulnerable when exposed to microwaves.

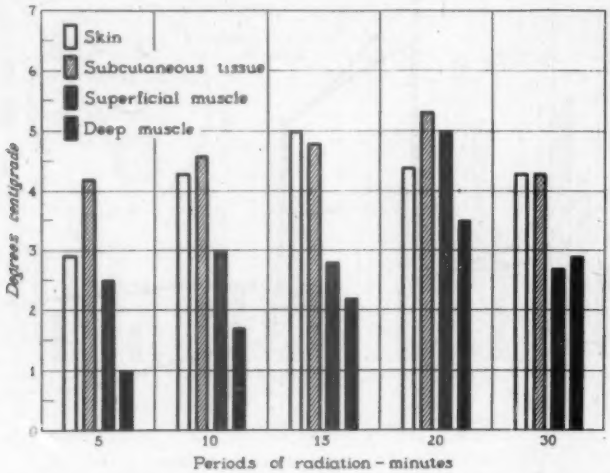

Fig. 6. — Temperature rises after microwave irradiation on thigh of intact dog. The increases of temperature after various periods of exposure represent an average of 25 studies distributed as follows: 4 exposures for five minutes, 5 for ten minutes, 6 for fifteen minutes, 5 for twenty minutes and 5 for thirty minutes. Exposure for thirty minutes produced less increase of temperature than did exposure for twenty minutes.

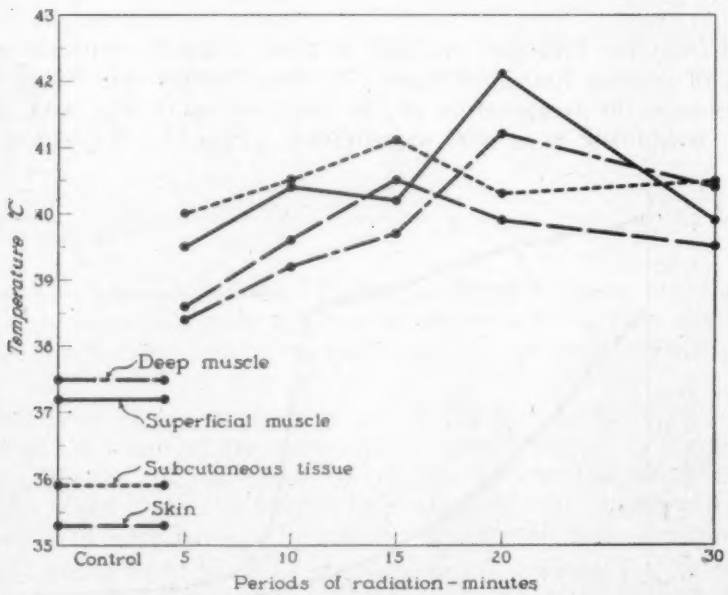

Fig. 7. — Temperatures in the tissues of thighs of intact dogs before and after microwave irradiation. The control temperatures represent the average temperatures before exposure. The dots represent the average of the highest temperatures recorded after the specified period of exposure.

An interesting physiologic phenomenon is demonstrated in figure 5. The rate of cooling of the muscle with circulation intact was moderately rapid

and resulted in a smooth curve, while the rate of cooling of the ischemic muscle was slow, even though it was heated to a higher temperature. On release of the aorta, cooling took place rapidly, and within two minutes the rate of cooling followed that of normal tissues.

Effects of Microwaves on Tissues with Intact Circulation. — For this study trained dogs were used. It was surprising to find that short periods of exposure to microwaves produced such high temperatures in the skin and subcutaneous tissue (fig. 6). The rises in the temperature of the superficial muscles were about the same after all except the exposures for twenty minutes, which definitely produced markedly higher temperatures. The temperature of the deep muscle increased progressively with increasing duration of exposure up to the twenty-minute period, which gave the highest increase. When exposures for thirty minutes were used, the rise in temperature of all the tissue layers was smaller than that produced by twenty-minute exposures. It appears that the cooling factors are most effective after twenty minutes of exposure. Increased circulation, as shown previously,[4] is largely responsible for this cooling effect.

An interesting study of temperature gradients is presented in figure 7. Before exposure the gradient was from the skin to the deeper tissues, the deep muscle being the hottest. After various periods of exposure to microwaves the temperatures in the different tissue layers varied. In certain instances the muscle layers were the hottest, in others the subcutaneous layer. Thus it seems that the gradient may vary with the duration of exposure to microwaves.

Different technics of application of microwaves may produce different temperature gradients. Further studies may reveal that by varying not only the duration of exposure but the output of the generator and the distance of the director from the skin different gradients may be obtained.

Our photographic records also furnished data on the approximate time required for the tissue temperatures to return to within 0.5 degree (C.) or less of control levels after exposure for various periods (table 2). The heating effect after five minutes of exposure seems to last practically as long as after thirty minutes of exposure, namely, for an average of twenty to not more than thirty-five minutes.

TABLE 2. —*Duration of Effects of Heating.*

Observations	Minutes Required for Temperature to Return Control After Radiation for: 5 Min.	10 Min.	15 Min.	20 Min.	30 Min.
1	20	22	10*	27	28
2	20	18	21	28	21
3	18	21	25	41*	....
4	23	23	15	21	66*
5	....	25	23	23	20
6	....	....	25	....	....
Average	20	22	20	28	34
Without extremes	20	22	22	25	23

Final average = 22 minutes

* Extremes. It should be noted that the extremes are out of proportion to the other recovery periods, and, if eliminated, the average recovery period after all 5 periods of exposure are about the same.

Comment

The finding that areas of decreased circulation, localized accumulation of tissue fluids and bony prominences are vulnerable does not mean that microwave diathermy to these areas is contraindicated. It simply indicates

that such areas should be treated with caution.

The ability of fluids to absorb microwaves efficiently may prove to be a valuable therapeutic property.

Summary

Before and after exposure to microwaves, a comparative study was made of the temperatures of the skin, subcutaneous tissue, superficial muscle and deep muscle of the thigh of the dog with the circulation intact and after ischemia produced by clamping the abdominal aorta. Temperatures produced by exposure for five, ten, fifteen and twenty minutes were measured by means of a thermistor and thermocouples. The temperature rises in the ischemic tissues were slightly higher than in normal tissues but were not considered significant after five or ten minutes of exposure, nor was there any evidence of burning after exposure for these shorter periods. After fifteen to twenty minutes of exposure, the increased temperatures in ischemic tissues were considered significant, and out of 11 experiments made after exposure for these longer periods, gross evidence of burning was noted in 10. In several instances burning occurred at temperatures that were lower than those seen after exposure of tissues with intact circulation in which no burning occurred. Temperatures tolerated by normal tissues cannot be regarded as the safe range of tolerance for ischemic tissues.

Bony prominences were potential sites for formation of blebs. If an area containing blebs was allowed to cool to control level and again irradiated with microwaves, the temperature of the fluid in the blebs would rise to levels significantly higher than that of the surrounding tissues.

In addition to the preceding experiments, another aspect of this study was made with trained dogs in order to determine the optimal duration of exposure to microwaves. Exposures for five, ten, fifteen, twenty and thirty minutes were used. Of these various durations of exposure, the twenty-minute period gave maximal heating.

A COMPARATIVE STUDY OF SHORT WAVE AND MICRO-WAVE DIATHERMY ON BLOOD FLOW *

The Role of the Somatic and Sympathetic Nerves in the Vascular Response to Deep Tissue Heating

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Introduction

It has been universally accepted that local heating of an extremity increases the blood flow to it. Recently, however, Kemp, Paul and Hines[1] have reported that, although blood flow in the femoral artery of the dog is increased by microwave diathermy, heating with short wave diathermy left blood flow unchanged or actually decreased. If this work could be confirmed, it would necessitate a complete revision of the present concepts of the physiologic effects of heating. To this end, the effects of microwave and short wave diathermy upon blood flow in the femoral artery were studied in a series of normal dogs and dogs with unilateral denervation of the hind extremity.

Methods

The studies were carried out upon pentobarbital-anesthetized dogs in a room kept at 30 ± 1 C. The high room temperature was necessary to prevent loss of body heat and a rapid fall in flow in the femoral artery.

The animals were placed on their backs in a troughlike dog board with the hind extremities partially extended and supported on approximately the same level as the trunk. The femoral arteries were exposed bilaterally from the inguinal ligament distally about 10 cm. The arteries were cannulated proximally and distally as close to the inguinal ligament as possible and without severing the arteries in order to prevent retraction. The cannulas were attached on each side to "bubble flow meters" which were slight modifications of the design of Leden and coworkers.[2] Readings were taken bilaterally and simultaneously. To prevent clotting 100 mg. of dicumarol was given orally twenty-four hours before operation and 100 mg. of heparin intravenously at the time of operation.

In addition, an iron-constantan thermocouple inserted into a 16 gauge hollow needle was placed into the gastrocnemius muscle to measure temperature before and after heating. These readings were taken only to be certain that a fair degree of heating had been produced; for, of course, temperature change depends not only on the energy absorbed but also on the rate of heat dissipation by the changing blood flow.

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* From the Departments of Physiology and Physical Medicine, Northwestern University Medical School. This work was aided by a grant from The National Foundation for Infantile Paralysis, Inc.
* Read at the Twenty-Sixth Annual Session of the American Congress of Physical Medicine, Washington, D. C., Sept. 8, 1948.

1. Kemp, C. P.; Paul, W. P., and Hines, H. M.: Arch. Phys. Med. 29:12, 1948.
2. Leden, V. M.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: Brit. J. Phys. Med. 101:177, 1947.

Microwaves (frequently of 2,450 megacycles) were applied by means of a "four inch director" placed 2 inches from the skin. Short wave (induction method) diathermy (frequency of 27.33 megacycles) was applied by means of a standard hinge-jawed drum adjusted to surround the leg. In both cases, after a one hour control period, heating was directed to the region of the gastrocnemius for twenty minutes.

The dogs with unilateral denervation of the hind extremity had one of three following lesions: section of ventral nerve roots from the fourth to the seventh lumbar segment; section of dorsal and ventral roots from the fourth to the seventh lumbar segment, or section of femoral, sciatic and obturator nerves peripherally. These animals were studied twelve weeks after production of the lesions. It is well to point out the exact type of lesions with which we were dealing. There is good agreement[3] that in a variety of animals the major sympathetic outflow to the hind extremities occurs between thirteenth thoracic and the third lumbar segment, and with an occasional contribution from the fourth lumbar roots. From the observations of Huddleston and White[4] and Frederick of this laboratory,[5] the major motor outflow to the muscles of the dog's leg occurs from the fourth to seventh lumbar roots. For these reasons, it is possible to produce a complete motor paralysis of these muscles with a minimum of interference with sympathetic supply. These lesions also resulted in a considerable paralysis of the thigh muscles. Since all available evidence[6] indicates that the sympathetic fibers to an extremity are contained in its somatic nerves, peripheral nerve section should produce a total denervation. Thus, the experimental animals represented three distinct types of lesion: (a) pure motor loss; (b) combined motor and sensory loss, and (c) motor, sensory, and autonomic loss.

To compensate for distortion resulting from spontaneous fluctuations in blood flow, flow changes were analyzed on the basis of the difference between control and heated sides just before and at the end of heating. This is designated "adjusted flow increase." Statistical significance was determined by the method of paired comparison.

Results

An examination of table 1 and chart 1 reveals that there is a significant increase in blood flow upon the application of either form of heating in normal animals and animals with root lesion. Because of the limited number of animals with root lesions, the results are grouped for analysis and presentation according to the type of heating. In all cases the response is essentially the same.

In dealing with the peripheral nerve lesion group it became obvious that the response typical of the other animals could not be obtained. Since there were not enough dogs in the peripheral nerve lesion group to permit separate analysis of microwave and short wave heating and since it was quite clear that the two methods of heating were equally effective in the other groups, for purposes of comparison the animals were arranged according to the type of lesion represented. These data assembled in table 2 and chart 2 demonstrate that while the response in the animals with root lesions is essentially

3. Langley, V. N.: Physiol. 12:347, 1891. Sheehan, P., and Marrazzi, A.. S.: J. Neurophysiol. 4:68, 1941.

4. Huddleston, O. L., and White, C. S.: Am. J. Physiol. 138:772, 1943.

5. Frederick, J. N.: Unpublished observations.

6. Woollard, H. H.: Heart 13:319, 1926. Blair, P. M., and Bingham: J. Anat. 63:162, 1928. Morton, J. J., and Scott, W. V.: J. Clin. Investigation 9:233, 1930. Woollard, H. H., and Phillips: J. Anat. 67:18, 1932.

TABLE 1. — *The Effect of Short Wave and Microwave Diathermy upon Blood Flow.*

Type of Animal	Type of Heating	No. of Animals	Mean Blood Flow, cc. Min. Before Heating: Control Leg	Mean Blood Flow, cc. Min. Before Heating: Leg Selected for Heating	Mean Blood Flow, cc. Min. After Heating: Control Leg	Mean Blood Flow, cc. Min. After Heating: Leg Selected for Heating	Mean Adjusted Flow Increase and Standard Deviation		T Ratio	Temperature of Gastrocnemius °C.: Before Heating	Temperature of Gastrocnemius °C.: After Heating	Temperature of Gastrocnemius °C.: Mean Increase in Temperature, °C. and Standard Deviation		T Ratio
Normal	Short wave	10	51.5	52.9	42.7	60.6	16.5	6.8	2.43*	37.9	41.5	3.6	.76	8.61†
Normal	Micro-wave	10	44.8	47.0	42.2	59.0	14.6	5.3	2.75*	38.4	43.6	5.2	.87	11.1
Ventral and dorsal-ventral root section	Short wave	7	33.4	31.5	28.1	36.7	10.5	3.55	2.96*	37.8	41.6	3.8	1.7	4.1†
Ventral and dorsal-ventral root section	Micro-wave	9	29.6	29.2	21.0	39.9	19.5	3.43	5.69†	37.7	43.9	6.2	1.1	10.5†

* Significant on 5 per cent level.
† Significant on 1 per cent level.

the same as in the normal dogs, significant increases in flow could not be obtained in those animals subjected to peripheral nerve section.

Comment

These experiments clearly demonstrate that short wave and microwave diathermy are equally effective in producing increased blood flow in the hind extremities of normal dogs.

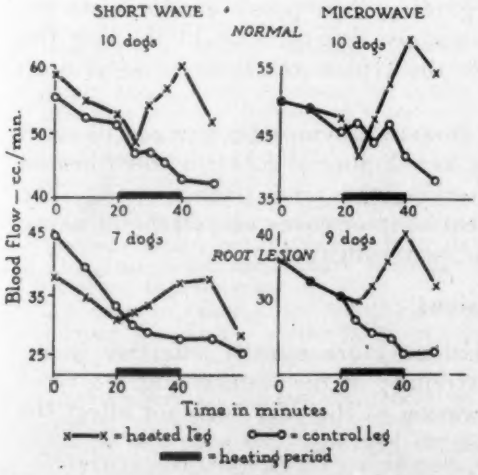

Chart 1. — Blood flow in normal dogs and dogs with root lesions upon application of short wave and microwave heating.

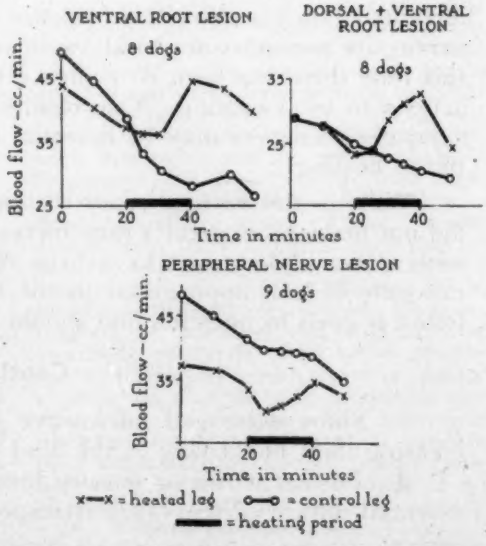

Chart 2. — Blood flow in dogs with ventral root lesion, ventral and dorsal root lesion and peripheral root lesion.

TABLE 2. — *The Effect of Various Nerve Lesions upon the Vascular Response to Heating.*

Type of Animal	Type of Heating	No. of Animals	Mean Blood Flow, cc. Min. Before Heating: Control Leg	Mean Blood Flow, cc. Min. Before Heating: Leg Selected for Heating	Mean Blood Flow, cc. Min. After Heating: Control Leg	Mean Blood Flow, cc. Min. After Heating: Leg Selected for Heating	Mean Adjusted Flow Increase and Standard Deviation		T Ratio	Temperature of Gastrocnemius °C.: Before Heating	Temperature of Gastrocnemius °C.: After Heating	Mean Increase in Temperature, °C. and Standard Devitation		T Ratio
Ventral root section	Short and Microwave	8	38.0	36.8	27.6	44.9	17.9	4.9	3.65*	37.1	42.2	5.1	2.5	5.43*
Dorsal and ventral root section	Short and microwave	8	24.6	23.6	20.6	32.2	13.8	3.1	4.52*	38.4	43.7	5.3	1.4	10.19*
Peripheral nerve section	Short and microwave	9	41.8	33.1	38.5	34.7	5.0	4.7	1.06	37.9	42.8	4.9	1.1	7.76*

* Significant on 1 per cent level.

On examining the data of Kemp, Paul and Hines,[1] one notes that, when microwave diathermy was successfully applied, the initial flow rates averaged 62.5 cc. per minute and increased with heating to an average of 101.7 cc. per minute. However, in their unsuccessful attempts to increase blood flow with short wave diathermy, the initial flow readings averaged 104.3 cc. per minute, or about the same as the average increase after microwave heating. Thus it may be possible that the extremities of the dogs used in the short wave diathermy experiments were initially in a state of vasodilation, which may have masked any vascular response to heating.

Although the root lesion animals, whose sympathetic nerves were intact, responded to heating in essentially the same manner as the normal dogs, the peripheral nerve lesion animals, whose sympathetic outflows had been interrupted, failed to show this response. It is well known that the sympathetic nerves are necessary for local vascular reactions of the extremities.[7] Up to this time there has been no evidence regarding their possible role in the reactions to local heating. Our results strongly suggest that in the dog the sympathetic nerves may be essential for the typical reactions to local deep tissue heating.

Wilkins and Eichna[8] reported that in man a sympathectomized forearm did not undergo as great a flow increase as the normal forearm when heated with water. They may have been observing the same phenomenon. The rationale of heat applications in the treatment of cases of peripheral nerve lesion is open to question and should be reinvestigated.

Conclusions

1. Short wave and microwave diathermy are equally effective in increasing local blood flow in the hind extremity of the normal dog.

2. Loss of motor or sensory innervation to the part does not affect the essential nature of the vascular response to heating.

7. Abramson, P. I.: Vascular Responses in the Extremities of Man in Health and Disease, Chicago, University of Chicago Press, 1944, p. 98.

8. Wilkins, R. N., and Eichna, L. W.: Bull. Johns Hopkins Hosp. 68:425, 1941.

3. Evidence is presented suggesting that the integrity of the sympathetic outflow in the dog is necessary for the typical vascular response to local heating.

4. There is no evidence that any known method of heating possesses properties which have any specific effect on blood flow.

Discussion of Papers by Siems, et al., and Worden, et al.

Dr. Harry M. Hines (Iowa City): Osborne and Holmquest have pointed out that the effectiveness of diathermy for producing tissue temperature elevation will depend upon (1) the efficiency of the circulating blood in dissipating the heat generated; (2) the thermal conductivity of the contiguous tissues; (3) the thermal capacity of the tissues absorbing the energy, and (4) the rate at which energy is being absorbed. It seems to me that a fifth factor must be considered—namely, the effect of the local hyperthermia upon the metabolism and consequent heat production in the treated tissue itself. The augmented heat production would result from the hyperthermia produced by diathermy but would involve a different mechanism. For example, a rise of body temperature of 9.4 degrees (F.) has been found to increase the heat production of the body by 65 per cent. Probably a much higher per cent increase would be found for such tissue as muscle. Comparable increases in the limb tissue temperature of dogs can be produced by short wave diathermy and by microwaves. The tissue temperature increases when measured at cutaneous, subcutaneous, 1.5 cm. and 3 cm. levels show a temperature rise gradient which decays from without inward. The temperature decline following irradiation is similar in these two frequences of electromagnetic waves.

My colleagues and I have been able to confirm the findings as to the effects of ischemia upon tissue temperature increases. In addition, I wish to point out that the fluids in avascular or relatively avascular areas present vulnerable target areas for overheating effects during irradiation treatments with microwaves. We have found that a single treatment for ten minutes at a director distance of 5 cm. with a power output of 100 watts raises the corneal temperature of rabbits to 46 C. (vitrous humor temperature = +49 C.). In many animals after a single treatment of this type lenticular opacities or cataracts develop within six to twenty-four days. This observation would have been missed in acute experiments.

I wish to make a few comments concerning the effect of diathermy upon blood flow. It is well recognized that heat usually causes vasodilation in cutaneous and other superficial tissues, but there is a paucity of information concerning the effect of heat upon the blood flow through deeper tissues, such as skeletal muscle.

Siems, Kosman and Osborne have confirmed our findings as to the effects of heating with microwaves upon blood flow in the hindlimbs of anesthetized dogs. In both laboratories diathermy treatments failed to increase the blood flow through denervated limbs. I agree with the conclusion, "The rationale of heat applications in the treatment of cases of peripheral nerve lesion is open to question and should be reinvestigated."

Siems, Kosman and Osborne found an increase at the 5 per cent level in the blood flow of the hindlimbs of anesthetized dogs treated with short wave diathermy. In our laboratory the average values for blood flow during short wave diathermy showed a decrease. In our series of dogs treated with short wave diathermy the final temperature of the gastrocnemius averaged 103.6 F.; in Siems, Kosman and Osborne's experiments the final temperature averaged 106.7 F. — i. e., over 3 degrees higher. Our final muscle temperatures with microwave treatment averaged 108.3 C.; theirs averaged 110.5 F. Mr. Siems has called your attention to the apparent differences in the initial levels of blood flow prior to treatment in the experiments in the two laboratories. I believe that equal temperature changes produced by treatment with either short wave or microwave diathermy will be accompanied with comparable vascular changes.

Finally, I wish to point out that the changes in blood flow as reported, whether a decrease or an increase, are of a low order. One must consider that a part of the change in blood flow is due to cutaneous dilatation. If one could correct his observed values for cutaneous flow changes, what would be his conclusions as to the effect of diathermy treatments on the blood flow through muscle? The changes in over-all blood flow during diathermy are of a low order and do not compare in magnitude with those resulting from slight activity or exercise and from the use of peripheral dilator drugs. I am not convinced from the evidence at hand that the alleged beneficial effects of diathermy treatments are related to changes in the blood flow through deep tissues. However, it must be admitted that this form of treatment might be much more effective in cases of blood vessel spasm or marked constriction than in cases of normal vessels. The experiments which have been discussed should be repeated, if possible, upon unanesthetized animals and by methods which permit the measurement of the blood flow through the deep tissues only.

Dr. William Bierman (New York): I should like to ask a question on a topic which Dr. Hines touched on in the very last sentence or two, as to the effect of the anesthesia itself when used in these exper-

imental animals upon the status of the sympathetic nerves and, therefore, on the blood flow?

Has anybody demonstrated that the sympathetic nerves control blood flow in the muscles of dogs? We have not found it to be so in the muscles of human beings. That finding, which we reported a goodly number of years ago, was supported by the work of Pickering in Sir Thomas Lewis' laboratory, indicating that the sympathetic nerves do not control the blood flow in muscles.

I should like to ask a third question of Dr. Worden. Does he think that the phenomenon he described of a gradual increase in temperatures for an initial period of twenty minutes, followed by a decline, is at all characteristic of this particular method of heating? My colleagues and I have observed as a universal occurrence in all methods of heating that there is a gradual increase to a maximum level (and in our own observations that level has been reached usually in between twelve and fifteen minutes) and then there is a decline to a plateau.

It would be interesting for some experimental workers to determine just what accounts for what we have referred to as a sort of "second wind" of the circulatory system, which seems to be able to handle that increased thermal energy.

Mr. Siems (closing): I should like first to answer Dr. Bierman's question regarding anesthesia. Pentobarbital anesthesia will certainly greatly increase peripheral blood flow, perhaps as much as two or three times its control level. However, this effect wears off in ten or fifteen minutes. It was with this fact in mind that we decided upon a one hour control period before instituting any heating, hoping by this means to eliminate any vasodilatory effect of the pentobarbital, or at least keep it at a minimum, since apparently its effect was in the initial stages of the anesthesia.

I have no wish to enter into a "cat and dog fight" with Dr. Hines on just why our results differ, or what are the possible reasons. The reason for presenting this paper here was simply to demonstrate that heat is heat. In other words, it makes no difference whether it be diathermy, short wave diathermy or microwave diathermy, the effect is essentially the same and the apparently limiting factor or positive factor is the amount of heat obtained.

I quite agree with Dr. Hines that we do not know where this increased blood flow is occurring, and, as taken up in our laboratory, we could conceive of no way of finding out.

Dr. Worden (closing): When tissues are heated locally by any method, the circulation would be expected to increase as the temperature increases. After a period of time the circulation may become so efficient that it carries off more heat from the tissues than is being put into the tissues.

When the method of heating is microwave diathermy, it has been shown by Leden and coworkers that during a twenty minute period of irradiation the circulation gradually increases and in some cases the peak is reached two or three minutes after the microwaves have been turned off.

When comparing the effect of microwaves and, for example, infra-red rays on the circulation, one might expect with microwave diathermy an increase in circulation of the deeper tissues relatively soon, because of good penetration and absorption. Infra-red radiation heats superficially, and the deep tissues receive heat secondarily by conduction; thus the increase in circulation of the deeper tissues might be comparatively slower.

EXPERIMENTAL LENTICULAR OPACITIES PRODUCED BY MICROWAVE IRRADIATIONS *

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IOWA CITY

While the development of cataract by means of irradiations is not new, having been established by various investigators (Bellows),[1] work in the past has been concerned chiefly with the effects of infra-red, ultraviolet and roentgen irradiations. In 1926, in a survey of work in these fields, Duke-Elder[2] suggested that future work might disclose many other portions of the spectrum to have pathogenic effects on the eye, if the energy were of sufficient magnitude.

Sinus disorders have been treated extensively by the use of short wave diathermy for a number of years. Such irradiations have proved to be safe when used as prescribed. Montcreiff, Coulter and Holmquest[3] irradiated the eyes of dogs in vivo with diathermy, 600 ma., for fifteen minutes and reported temperature rises of 6.54 and 6.98 degrees Centigrade in the anterior chamber and posterior segment. This dosage was considered to be safe.

With the production of a new microwave generator by Raytheon which propagates 12.25 cm. waves, a new band of the electromagnetic spectrum has been offered for medical therapy. Krusen, Herrick, Leden and Wakim,[4] found that these microwaves effectively heated the highly vascularized musculature of the dog. Osborne and Frederick[5] reported that temperatures were adequately induced in the highly vascularized tissues of both human subjects and dogs when standard testing procedures were followed. In acute experiments exposing the eye of the dog to an output of 75 to 100 watts at a distance of 5.08 cm. the temperature of the vitreous was increased to an average of 41 C. (maximum 44.4 C.). On examination immediately following the irradiations, no pathologic effects were found in the eyes.

The studies of these groups have been concerned predominantly with temperature increases induced in body tissues, including the eye, and in the immediate changes produced. The purpose of our observations was to study more thoroughly both the immediate and the delayed effects of microwave irradiations upon the eye. It was thought that since the center of the eye is a relatively avascular area it might be less capable of heat dissipation than other more vascular tissues. We have found that this form of radiation is highly productive of experimental lenticular opacities.

Procedure

The Raytheon 12.25 cm. microwave generator model CMD4 was used throughout the experiments. This machine delivers a peak output of 125 watts, but in all cases an output of 100 watts was employed with use of the rectangular corner type wave

* From the Department of Physiology, College of Medicine, State University of Iowa.

1. Bellows, J. G.: Cataract and Anomalies of the Lens, St. Louis, C. V. Mosby Company, 1944, chap. 7.
2. Duke-Elder, W. S.: Pathological Action of Light Upon the Eye, Lancet 1:1188, 1926.
3. Montcreiff, W. F.; Coulter, J. S., and Holmquest, H. J.: Experimental Studies in Diathermy Applied to the Eye and Orbit, Am. J. Ophth. 15:194, 1932.
4. Krusen, F. H.; Herrick, J. F.; Leden, U., and Wakim, K. G.: Preliminary Report of Experimental Studies of the Heating Effect of Microwaves, Proc. Staff Meet., Mayo Clin. 15:194, 1947.
5. Osborne, S. L., and Frederick, J. N.: Microwave Radiations, J. A. M. A. 137:1036, 1948.

director. Care was exercised to avoid any undesirable standing waves in the coaxial cable which might be produced by large metal objects or other artefact-initiating conditions. Animals were irradiated on wood laboratory tables, while excised eyes were irradiated on rectangular Plexiglas pedestals. These precautions were taken to insure consistent optimal temperature measurements.

During and after exposures, temperature measurements were taken by means of iron-constantan thermocouples housed in hypodermic needles as described by Tuttle and Janney.[6] Potentials were recorded on a Leeds and Northrup type 8662 potentiometer, and temperature measurements were calibrated with a bureau of standards thermometer.

In order to eliminate the possibility that the temperature readings might be measurably affected by the presence of the thermocouple in the field of microwaves other than from tissue temperature per se, we irradiated one group of animals with the thermocouple in situ and compared this with another group in which the thermocouple was introduced immediately after the irradiation period. There was no significant difference between the temperatures recorded in these two groups of experimental eyes.

When intact eyes were irradiated throughout the experiments, 3 to 5 Kg. albino rabbits were employed in vivo and post mortem. Rabbits exposed in vivo were anesthetized with Nembutal or urethane. Such animals received drops of atropine and Pontocaine previous to exposure in order to minimize irritability and assure a uniform size of the pupil. In experiments upon excised eyes, both normal mongrel dogs and albino rabbits were used.

The wave director was alined directly on and at a right angle to the optic axis in all cases, and the distance was measured from the plastic director housing to the cornea. Internal eye temperatures were taken by inserting a thermocouple into the posterior segment until the tip rested in the vitreous at the posterior pole of the lens.

These animals were maintained on sufficient water and Purina laboratory food during the experiments to insure an adequate diet. They were kept in well ventilated rooms moderately lighted with indirect sunlight. The eyes were inspected by use of a hand slit lamp and ophthalmoscope prior to irradiation, immediately after and at daily intervals.

Results

Excised Eyes; Rabbits and Dogs. — This series of observations was designed to study any lenticular changes resulting from irradiation upon an isolated, and thus avascular, system. When the temperatures of the excised eyes were progressively increased in successive irradiations from 34.5 to 70.1 C., it was found that while temperatures of 45.6 C. and below produced no observable damage, temperatures of 66.2 C. and above resulted in lenticular opacities. Seven measurements were made in this series, the results of which may be seen in table 1. These eyes were exposed at distances of 1 to 5 cm. for three minutes each.

TABLE 1. — *Temperatures and Lenticular Changes Induced in Excised Eyes of Dogs and Rabbits Immediately After Microwave Irradiation of 100 Watts at 1 to 5 Cm. Distances for Three Minutes.*

No.	Temperature °C.	Lens
1	34.5	.....
2	43.6	.....
3	45.0	.....
4	45.3	.....
5	45.6	.....
6	66.2	Opacity
7	70.1	Opacity

The lenticular opacities produced by irradiation under these conditions were located at the posterior pole of the lens and resembled cataracts produced by infra-red irradiation.

Eyes Intact Post Mortem; Rabbits. — In this series, lenticular changes were produced and the minimum temperatures necessary for their formation

6. Tuttle, W. W., and Janney, C. D.: The Construction, Calibration and Use of Thermocouples for Measuring Body Temperatures, Arch. Phys. Med. 29:416, 1948.

were more clearly defined, the same conditions of exposure being employed as for excised eyes—i. e., 1 to 5 centimeters distance for three minutes. Another group was added which was irradiated for fifteen minutes in order to obtain a slightly higher range of temperatures. The results of the irradiations of these two groups of animals are shown in table 2.

TABLE 2. — *Temperatures and Lenticular Changes Induced in Intact Eyes of Rabbits Postmortem Immediately After Microwave Irradiation of 100 Watts at 1 to 5 Cm. Distances.*

No.	Time, Minutes	T° C.	Lens
1	15	50.0	.....
2	3	53.5	.....
3	3	54.8	Opacity
4	15	55.3	.....
5	15	59.3	Opacity
6	3	60.0	Opacity
7	15	60.2	Opacity
8	15	61.8	Opacity
9	3	63.9	Opacity
10	15	67.5	Opacity

It may be seen that in the ascending scale of induced temperatures the results were negative to 54.8 C., a point at which traces of lenticular opacity were observed. At temperatures recorded above this, distinct cataractous opacifications were observed in all eyes except 1 which was increased to 55.3 C. In this eye, no lenticular changes were evident.

Upon the assumption that opacities were produced in the eye at induced temperatures of approximately 55 C., the next endeavor was an attempt to reproduce this condition in the eyes of living animals.

Eyes Intact in Vivo; Rabbits. — Using anesthetized albino rabbits, we made seven temperature measurements of the cornea and six of the vitreous at the posterior pole of the lens when irradiated at a distance of 5 cm. Temperatures were recorded at one minute intervals, during irradiation. The results are shown in chart 1. It was found that the average temperature at the posterior pole of the lens was increased to 55.1 C. in fifteen minutes, whereas the average temperature of the cornea at that time was 49.4 C. However, it was of some interest to observe that no opacities of the lens were present under these conditions.

Studies were continued further on 4 animals which were irradiated for seventeen to twenty minutes at a distance of 5 cm. Immediate examination with a hand slit lamp revealed opacities in the lens in all cases.

Upon a basis of this information, 3 animals were irradiated for seventeen minutes and 6 for fifteen minutes at a distance of 5 cm. without temperature measurements. Examined daily, in three to nine days in all the former and 5 of the latter lenticular opacities had developed. Since it was disclosed by these observations that cataractous changes could be developed many days following exposure and by irradiations of a smaller magnitude than those which produced an immediate opacity, further investigations were made with multiple exposures of yet smaller magnitudes on alternate days.

Six animals were given three exposures, each of twelve minutes' duration, at a distance of 5 cm., conditions which, judging from previous experiments, increased the temperature at the posterior pole of the lens to 53 C. In 3 of these animals opacities developed in two to ten days. A fourth revealed an opacity in forty-two days.

Four animals were irradiated for ten minutes' duration at 5 cm., raising the posterior lenticular temperature to an estimated 52 C., the number of

exposures in each case being three, four, six and seven. Under these conditions, 3 of the 4 animals showed lens changes in fifteen days. However, when 3 animals were given six exposures of three minutes each at 5 cm., previously shown to cause a 47.1 C. temperature at the posterior pole, no opacity was present upon observation at the end of four months.

Another series of animals was studied under conditions wherein the temperature of the cornea was raised rapidly and maintained for ten minutes. Six albino rabbits were employed in the first group, in which the temperature of the cornea was increased to 46 C. in an average time of three minutes and maintained at that temperature for ten minutes longer. In 4 of the 6 cataracts developed in six to twenty-four days. However, when the corneal temperatures of 5 animals were increased to 40 C. in an average time of one minute and maintained at that temperature for ten minutes longer, no opacity of the cornea or lens was apparent after thirty days.

A summary of these findings may be seen in table 3. In all cases the opacities were permanent. There was other occasional damage to the eyes, such as retinal hemorrhage and bleeding into the vitreous.

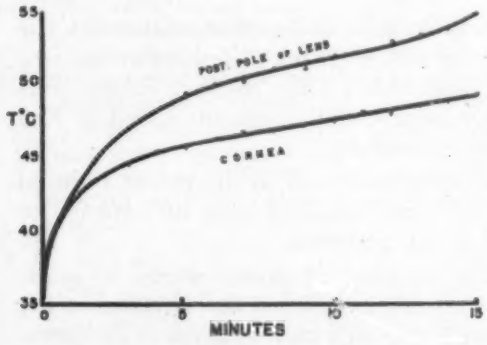

Chart 1. — In vivo corneal and lenticular temperatures of rabbit eyes irradiated with 100 watts of 12.25 cm. microwaves at 5 cm.

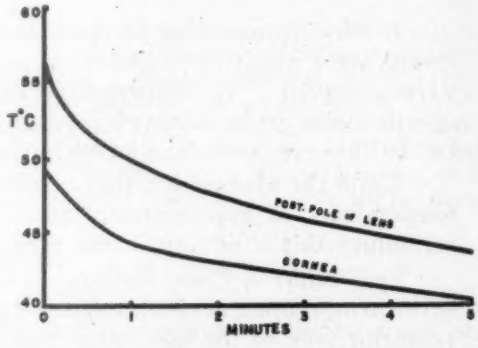

Chart 2. — In vivo corneal and lenticular temperature decay in rabbit eyes following irradiation with 100 watts of 12.25 cm. microwaves at 5 cm.

TABLE 3. — *Summary of Results of Microwave Irradiations of Rabbit Eyes in Vivo at 5 Cm. Distance for Exposures of 3 to 20 Minutes.*

Group	Number of Exposures	Min. of Each Exposure	Number in Group	Number With Cataract	Per Cent With Cataract
100 watt exposure					
1	1	17–20	4	4	100
2	1	17	3	3	100
3	1	15	6	5	83.3
4	3	12	6	4	66.7
5	3, 4, 6, 7	10	4	3	75
6	6	3	3	0	0
Corneal temperature maintained at 46 C.					
7	3	10	6	4	66.7
Corneal temperature maintained at 40 C.					
8	3	10	5	0	0

In order to ascertain any discrepancies between temperature measurements taken continuously in the field and those taken after irradiation, temperature decay gradients following irradiation were plotted. Chart 2 represents the average temperature decay of the cornea and vitreous at the posterior pole of the lens over a five minute period following irradiation. It may be seen that there is a marked temperature drop during the first minute.

Of the 54 eyes which were irradiated under the various experimental conditions described, 32 were found to contain lenticular opacities. These opacities varied from small posterior polar masses to almost complete opacifications of the lenses completely obscuring the retina.

Comment

Since other workers have shown that the microwave generator serves an adequate purpose in medical therapy by inducing temperature increases in selected areas of the body, the findings in this report should not in any way discourage its employment in those areas as a thermogenic device. However, it is believed that precaution should be taken in the future with regard to irradiations in the region of the orbit. Although the conditions described in this report included irradiations of a greater magnitude than those routinely employed in therapy, it is noteworthy that the observations were carried out in all cases for a duration of less than twenty minutes.

These experiments suggest that precautionary measures may be of value to workers and patients frequently exposed to the radiations of microwave generators. It has been found by tests with microammeters that fine mesh copper screen wire shields worn over the eyes effectively diminish 100 watt microwave irradiations.

The findings herein described may prove to be of benefit to ophthalmologic research workers desiring an effective method for producing experimental cataract.

Summary

1. A direct single exposure of rabbit eyes to 12.25 cm. microwaves at 5 cm. distance for fifteen minutes with 100 watts power output resulted in cataractous lenticular opacities after a delay of three to nine days.

2. Under the conditions just stated for single exposures, the average temperature of the vitreous at the posterior pole of the lens was found to be 55.1 C. while that of the cornea was found to be 49.4 C.

3. A series of repeated exposures of a smaller magnitude resulted in cataractous lenticular opacities after a delay of two to forty-two days.

4. Four rabbits irradiated for seventeen to twenty minutes at 5 cm distance revealed cataract formations immediately after the irradiations.

5. The practical applications of these microwaves are discussed. Until further data are accumulated, precaution should be observed in the use of microwaves in the region of the face and orbit.

EARLY AMBULATION IN SURGICAL CONVALESCENCE *

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Progress in the knowledge of the physiologic aspects of convalescence following surgery or disease has proceeded rapidly in the past few years. Consequently, many studies have been directed toward therapeutic measures designed to maintain nitrogen balance[1] and efficiency of the liver[1e, f] the muscles[2] and the cardiovascular and respiratory systems.[3]

In the United States interest in ambulation as a form of postoperative therapy was evinced as early as 1899 by Emil Ries,[4] who had patients walk on the first to third postoperative day. Unfortunately, this interest was not sustained, and sporadic attempts to revive it were not successful until recently.[5] Early ambulation has been empirically accepted as a therapeutic measure, although the physiology of many changes in the body thus induced is not too well known and the mechanism of its effectiveness remains unexplained.

Experimental Studies

General Description. — The purpose of this investigation was to develop methods and objective criteria for estimating the progress of convalescence after surgery and to apply such criteria to a study of the influence of early ambulation and dietary modifications in altering this rate of convalescence. A description of the division of the patients into groups and much of the detailed data have been presented elsewhere,[1e, f] This report is confined to

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The data presented in this report were secured in the course of a project covered by a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the University of Illinois.

1. (*a*) Elman, R.; Weiner, D. O., and Bradley, E.: Intravenous Injections of Amino Acids (Hydrolyzed Casein) in Postoperative Patients, Ann. Surg. 115:1160, 1942. (*b*) Brunschwig, A. D.; Clark, D. E., and Corbin, N.: Postoperative Nitrogen Loss and Studies on Parenteral Nitrogen Nutrition by Means of Casein Digest, ibid. 115:1091, 1942. (*c*) Mulholland, J. H.; Co Tui; Wright, A. M., and Vinci, V. J.: Nitrogen Metabolism, Caloric Intake and Weight Loss in Postoperative Convalescence; Studies of Eight Patients Undergoing Partial Gastrectomy for Duodenal Ulcers, ibid. 117:512, 1943. (*d*) Peters, J. P.: Problems of Nitrogen Metabolism, Federation Proc. 3:197, 1944. (*e*) Keeton, R. W.; Cole, W. H.; Calloway, N.; Glickman, N.; Mitchell, H. H.; Dyniewicz, J., and Howes, D.: Convalescence: A Study in the Physiological Recovery of Nitrogen Metabolism and Liver Functions, Ann. Int. Med. 28:521, 1948. (*f*) Cole, W. H.; Keeton, R. W.; Calloway, N. O.; Glickman, N.; Mitchell, H. H.; Dyniewicz, J., and Howes, D.: Studies in Postoperative Convalescence, Ann. Surg. 126:592, 1947.

2. Simonson, E., and Enzer, N.: Physiology of Muscular Exercise and Fatigue in Disease, Medicine, 21:345, 1942. Taylor, H. L., and Brozek, J.: Evaluation of Fitness, Federation Proc. 3:216, 1944.

3. Footnotes 1e and f and footnote 2.

4. Ries, E.: Some Radical Changes in After Treatment of Celiotomy Cases, J. A. M. A. 33:454, 1899.

5. Leithauser, D. J., and Bergo, H. L.: Early Rising and Ambulatory Activity After Operation: A Means of Preventing Complications, Arch. Surg. 42:1036, 1941.

an evaluation of the therapeutic effect of early ambulation on patients who submitted to herniorrhaphy. This is considered to be a light operative load.

The majority of the patients studied were young men referred by Selective Service, although a few of the older patients were admitted through the surgical dispensary. The ages ranged from 16 to 66 years and averaged 26.6 years. The patients were housed in two four bed wards, air-conditioned for comfort (23.3 C. dry bulb and 40 per cent relative humidity). This environmental temperature and humidity were maintained throughout the year, making the experiments more comparable by preventing excessive loss of fluids by sweating in the summer and tending to stabilize peripheral circulation.

The patients were required to report to the hospital six or seven days before operation. This period was devoted to stabilization of their diets, to tests and to prescribed exercises administered only to the patients selected for early ambulation. Table 1 describes the management of the groups discussed in this report.

TABLE 1. — *Management of the Groups.*

Group Number	Number of Patients	Preoperative Dietary Management	Postoperative Dietary Management	Anesthesia	Ambulation
II (Control Group)	10	Total calories B + 20%; protein calories 15%	Progressive increase in diet*	Nitrous oxide and ether	Absent
III	5	Total calories B + 100%; protein calories 20%; Supplements†	Diet maintained by tube feeding	Nitrous oxide and ether	Present
IV	6	Total calories B + 20%; protein calories 15%	Progressive increase in diet*	Spinal	Absent
V	7	Total calories B + 20%; protein calories 15%	Progressive increase in diet*	Spinal	Modified (push-up, step-up and psychomotor tests)
VI	8	Total calories B + 20%; protein calories 15%	Progressive increase in diet*	Nitrous oxide and ether	Present
XI	7	Total calories B + 20%; protein calories 40%	Diet maintained by tube feeding	Nitrous oxide and ether	Absent
XII	5	Total calories B + 20%; protein calories 40%	Diet maintained by tube feeding	Nitrous oxide and ether	Present
XIII	3	Total calories B + 100%; protein calories 10%	Diet maintained by tube feeding	Nitrous oxide and ether	Absent

* See text.

† Supplements: Preoperatively daily vitamins A, B complex, C and D and choline. Postoperatively daily vitamin K, liver extract, adrenal cortex extract, testosterone propionate, thiaminchloride, riboflavin, ascorbic acid, pyridoxine, calcium pantothenate, nicotinamide and choline, and, only on day of operation, methionine and amigen solution.

The ambulated patients were allowed out of bed on the first postoperative day and were discharged on the seventh day. With the exception of two groups (control groups II and V), all nonambulated patients were kept in bed postoperatively until the sixth day and were discharged from the hospital on the seventh day. The patients of group II were not ambulated; the patients of group V received a modified form of ambulation. The patients of both groups (II and V) were allowed out of bed on the tenth postoperative day and discharged on the twelfth day.

Groups II, IV, V and VI were fed a diet containing basal calories plus 20 per cent, with 15 per cent of the calories derived from protein. On the day of surgery after the operation, they were given 1,000 cc. of isotonic solution of sodium chloride and 1,000 cc. of 5 per cent glucose in distilled water intravenously. On the succeeding days they received 1/4, 1/2, 3/4 and 4/4, respectively, of their preoperative diets. The foods served each postoperative day contained the proportions of carbohydrate, protein and fat originally given. On the other hand, the patients of groups XI, XII and XIII were tube fed postoperatively until they were able to take all their diet by mouth. This insured continuous alimentation at the preoperative level throughout the postoperative period. The patients of all groups adhered strictly to their respective dietary regimens.

The anesthesia for all groups but two was nitrous oxide induction with ether maintenance. An attempt was made to approximate the same depth and duration of anesthesia for all patients. The other two groups (IV and V) received spinal anesthesia with tetracaine hydrochloride (Pontocaine).

To measure the physiologic effects of early ambulation the patients were

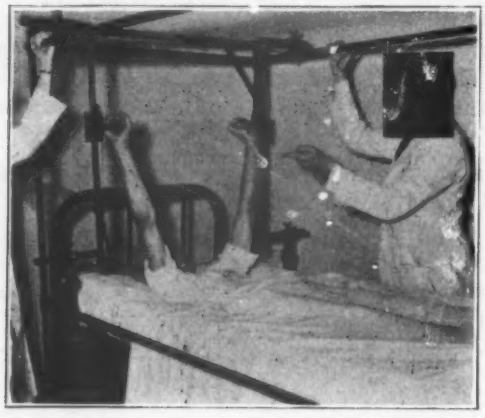

Fig. 1. — Apparatus for push-up test. The patient is required to raise and lower 20 pounds with each arm a distance of 1 foot at a rate of thirty times per minute for two minutes.

divided into paired groups. Group II, which received submaintenance calories postoperatively until the fourth day, was the control for group VI, which received similar treatment except that early ambulation was added. Similarly, group XI, which was tube fed postoperatively and received excessive protein, was the control for group XII, which received early ambulation in addition to the previously mentioned factors.

Description of the Exercises. — Early ambulation, as used here, refers to exercising patients preoperatively and, particularly, postoperatively. The exercises were resumed on the first postoperative day. They were designed to bring into play practically all the muscle groups of the body without placing undue stress on the abdominal muscles.

Preoperatively, the ambulation consisted of calisthenics performed twice daily, both in and out of bed. Most of the calisthenics used were slight modifications of those described by Stafford, De Cook and Picard.[6] The calisthenics in bed consisted of the push-up test (fig. 1) for two minutes (description of which follows), arm stretching, (upward and outward) for two

6. Stafford, G. T.; De Cook, H. B., and Picard, J. L.: Individual Exercises, New York, A. S. Barnes & Company, 1935.

minutes, toe creeper for two minutes, neck bend (forward and backward) for thirty seconds, deep breathing for one minute, ear presser (right and left hand to ear) for one and one-half minutes, knee presser (alternating legs) for two minutes and sit-up (with hands clasped behind head) for one minute. The calisthenics performed out of bed consisted of the diver's stance for thirty seconds, the toe stand (up and down supporting weight of body on toes of one foot) for one and one-half minutes (forty-five seconds on each foot), the two step climb (each step 9 inches high) for one minute, and the step-up (one foot remaining on the 9 inch step) for three minutes.

Postoperatively, the calisthenics were begun on the first day for nine minutes in the morning and eleven minutes in the afternoon. This included all the calisthenics given in bed except the sit-up, which was given only preoperatively. In addition, each patient stood beside the bed for three minutes and walked for one minute on the first postoperative day. On the second postoperative day and thereafter, the calisthenics in bed were taken with about the same vigor and the same duration as preoperatively. The patients walked short distances and remained out of bed for thirty minutes. On the third and fourth postoperative days the patients remained out of bed for two hours and four hours, respectively. On succeeding days the patients remained out of bed as they desired.

Statistical Analysis. — All data have been analyzed using "Student's" method[7] of determining the significance of the mean of a small series of paired differences or Fisher's modification[8] of this method as applied to differences between the means of small samples of unpaired observations. The probabilities given in the text are expressed in the "Student," rather than the Fisher, sense: They are the probabilities that a fortuitous combination of the uncontrolled factors in the experiment would give a difference between means as great as, or greater than, that observed, and in the direction observed. Probabilities of 0.03 or less are generally regarded as significant.

Results

There are many changes that go on within the body as a result of anesthesia, surgical trauma, semistarvation and bed rest, and some organs suffer greater and more prolonged impairment than others. Therefore, it is necessary to have reliable objective tests which measure certain functions. A description of the tests for metabolic, cardiovascular, respiratory and muscular efficiency used in this study has been presented elsewhere.[1f]

Early Ambulation and Liver Efficiency. — There have been many reports describing impairment of the liver following anesthesia and surgery.[9] In the present study, bromsulphalein clearance and daily twenty-four hour urinary urobilinogen excretion were the two tests used routinely to measure changes in the efficiency of the liver. Other functional tests were also utilized.[1f]

The data revealed that the observed impairment of the liver as measured by these two tests was not altered by early ambulation, with one exception. Group XII, which was tube fed postoperatively and received a diet high in protein in addition to early ambulation, showed significantly less ($P = 0.015$) impairment of the liver as measured by bromsulphalein clearance than group XI, which was treated identically except that early ambulation was omitted.

7. "Student": The Probable Error of a Mean, Biometrica, 6:1, 1908; New Tables for Testing the Significance of Observations, Metron, 5:105, 1925.
8. Fisher, R. A.: Statistical Methods for Research Workers, ed. 2, Edinburgh and London, Olive and Boyd, 1928.
9. Coleman, F. P.: The Effect of Anesthesia on Hepatic Function, Surgery 3:89, 1938. Bourne, W.: Anesthetics and Liver Function, Am. J. Surg. 34:486, 1936. Boyce, F. F.: The Role of the Liver in Surgery, Springfield, Ill., Charles C. Thomas, Publisher, 1941.

No satisfactory explanation on a metabolic basis for this isolated effect of early ambulation has been found.

Early Ambulation and Nitrogen Balance. — Considerable data have been accumulated revealing the negative nitrogen balance occurring in patients convalescing from surgical procedures.[10] The decreased nitrogen intake during the first few days following the operation is one of the most important factors contributing to this negative nitrogen balance. It has been shown[11] that by administering adequate calories high in protein during the postoperative period this negative balance can be prevented.

On the other hand, there is a paucity of metabolic studies designed to determine the effect of exercise on nitrogen balance. Thörner[12] reported a higher percentage of water in the muscles of trained dogs, and Embden and Habs[13] showed that the absolute dry weight also increased with training. The increase was partly in the acid-soluble nitrogen. Morpurgo[14] found from careful histologic studies on dogs that the increase in muscle mass which occurred after months of strenuous running exercises was due to a true hypertrophy of individual fibers. Talbott and associates[15] reported that an average of 1 Gm. less of nitrogen was excreted per day during the last six days than during the first thirteen days of training while on a constant diet. Keys and associates[16] observed a reduced blood volume and negative nitrogen balance[17] in normal subjects kept at bed rest. With resumption of activity, the blood volume increased and the nitrogen balance became positive. Deitrick and associa es[18] immobilized healthy subjects in casts. They found an increased excretion of nitrogen during the period of immobilization and a decreased excretion with storage when activity was resumed. They also observed[19] in 2 normal subjects immobilized in casts and placed in an oscillating bed that nitrogen losses were less than when the subjects were immobilized in a stationary bed.

The patients in this study were given diets calculated on the basis of their surface area, age and sex. The patients were divided so that nitrogen intake averaged about the same for comparable groups. As shown in table 2, no significant differences could be demonstrated in the preoperative or postoperative nitrogen intakes between group II (nonambulated) and group VI (ambulated) and between group XI (nonambulated) and group XII (ambulated), even though the nitrogen intake of group XI averaged 1.8 Gm. per day more than that of group XII. This difference was due to 2 heavier patients in group XI. Further, no significant difference could be demon-

10. (*a*) Co Tui; Wright, A. M.; Mulholland, J. H.; Carabra, V.; Bardram, I., and Vinci, V. J.: Studies on Surgical Convalescence: I. Sources of Nitrogen Loss, Postgastrectomy and Effect of High Amino-Acid and High Caloric Intake on Convalescence, Ann. Surg. 120:99, 1944. (*b*) Riegel, C.; Rhoads, J. E. Koop, C. E.; Grigger, R. B.; Bullitt, L., and Barrus, D.: Dietary Requirements for Nitrogen Equilibrium in the Period Immediately Following Certain Major Surgical Operations, Am. J. M. Sc. 110:133, 1945. (*c*) Riegel, C.; Koop, C. E.; Drew, J.; Stevens, L. W., and Rhoads, J. E.: The Nutritional Requirements for Nitrogen Balance in Surgical Patients During the Early Postoperative Periods, J. Clin. Investigation 26:18, 1947. Footnote 1 b, c, e and f.

11. Elman, R., and Akin, J. T.: A Design for Surgical Convalescence, Ann. Surg. 122:716, 1945. Elman, Weiner and Bradley.1a Co Tui and others.10a

12. Thörner, W.: Trainingsversuche an Hunden: 1. Der Einfluss der Laufarbeit auf das Herz, Arbeitsphysiol. 3:1, 1930.

13. Embden G., and Habs, H.: Ueber chemische und biologische Veränderungen der Muskulatur nach öfters wiederholter faradischer Reizung, Ztschr. f. physiol. Chem. 171:16, 1927.

14. Morpurgo, B.: Ueber Activitäts-Hypertrophie der willkürlichen Muskeln, Virchows Arch. 150: 522, 1897.

15. Talbott, J. H.; Folling, A.; Henderson, L. J.; Dill, D. B.; Edwards, H. T., and Berggren, R. E. L.: Studies in Muscular Activity, v. Changes and Adaptations in Running, J. Biol. Chem. 78:445, 1928.

16. Taylor, H. L.; Erickson, L.; Henschel, A., and Keys, A.: The Effects of Bed Rest on the Blood Volume of Normal Young Men, A. J. Physiol. 144:227, 1945.

17. Miller, E. V.; Michelsen, O.; Benton, W. W., and Keys, A.: The Effect of Bed Rest on Mineral and Nitrogen Balances, Federation Proc. 4:99, 1945.

18. Dietrick, J. E.; Whedon, G. D.; Shorr, E., and Barr, D. P.: Conference on Metabolic Aspects of Convalescence Including Bone and Wound Healing, Josiah Macy, Jr. Found., Ninth meeting, Feb. 2-3, p. 62, 1945.

19. Dietrick, J. E.; Whedon, G. D., and Shorr, E.: The Effect of Bed Rest and Immobilization Upon Various Chemical and Physiological Functions of Normal Men: Their Modification by the Use of the Oscillating Bed, Conference on Metabolic Aspects of Convalescence Including Bone and Wound Healing, Josiah Macy, Jr. Found. Twelfth meeting, Feb. 4, 1946.

strated for the average preoperative nitrogen balance between groups II and VI and groups XI and XII (table 3). The six-day preoperative nitrogen balance had to be calculated, since, in some cases, twenty-four hour urine collections were available for only four or five days before operation instead of six days. In such cases the average daily nitrogen balance was determined for the days available and multiplied by six. Table 3 also shows that no significant difference could be demonstrated between the average preoperative nitrogen excretion between groups II and VI and groups XI and XII. The ease with which nitrogen equilibrium was approximated in the preoperative period (fig. 2) indicated that the patients were in a good nutritional status. Of course, when the nitrogen intake was sharply increased (groups XI and XII, fig. 3), a positive balance during the preopreative period would be expected for a short period. Two patients of the original 7 have been omitted from group XI because they did not conform to the requirements of the experiment. One patient, on the second postoperative day, accepted only 4.6 of the 31.7 Gm. of nitrogen designated for him. The other patient had incomplete urine collections during the preoperative period, and it was therefore impossible to determine his preoperative nitrogen balance.

TABLE 2. — *Comparison of Preoperative and Postoperative Nitrogen Intake (in Grams) in Groups Receiving Similar Management Except for Ambulation.*

Group Number	Number of Patients	Average Daily Preoperative Nitrogen Intake	Probability	Average 6-Day Postperative Nitrogen Intake	Probability
II*	10	13.1		7.4	
vs			Insignificant		Insignificant
VI†	8	13.2		7.8	
XI*	5‡	30.3		30.4	
vs			Insignificant		Insignificant
XII†	5	28.7		28.6	

* Nonambulation.
† Early ambulation.
‡ Two patients omitted; see text.

TABLE 3. — *Comparison of Preoperative Nitrogen Balance and Nitrogen Excretion (in Grams) in Groups Receiving Similar Management Except for Ambulation.*

Group Number	Number of Patients	Average Daily Preoperative Nitrogen Balance	Probability	Average Daily Preoperative Nitrogen Excretion	Probability
II*	10	—0.2		13.3	
vs			Insignificant		Insignificant
VI†	8	—0.5		13.9	
XI*	5‡	+3.7		26.5	
vs			Insignificant		Insignificant
XII†	5	+3.7		25.0	

* Nonambulation.
† Early ambulation.
‡ Two patients omitted; see text.

The difference between the calculated total preoperative nitrogen balance over a six-day period and the nitrogen balance on the day of operation and each of the five succeeding postoperative days were obtained for each patient and constituted the "postoperative nitrogen balance difference." The "postoperative nitrogen excretion difference" was obtained in the same manner. The data detailed in table 4 reveal that group II had a negative balance of 31.1 Gm. of nitrogen for the six-day period including the day of

operation and, as calculated by the method given, a difference of 29.7 Gm. Group VI had a negative balance of 22.8 Gm. for the same period and a difference of 19.8 Gm. This difference between groups of 9.9 Gm. was statistically highly significant (P = 0.005). Group XI had a positive balance of 5.9 Gm. of nitrogen with a difference of 16.5 Gm. and group XII a posi-

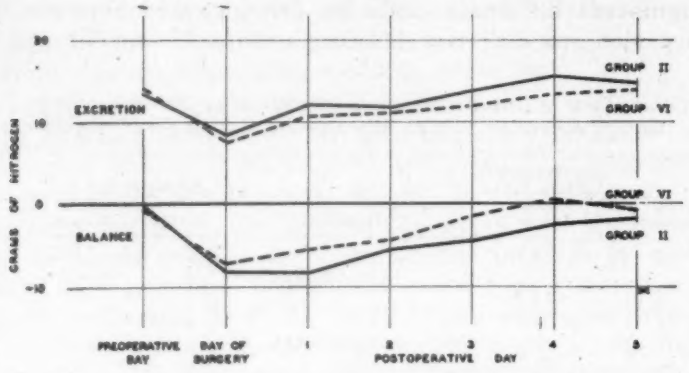

Fig. 2. — Preoperative average and postoperative daily nitrogen balance and excretion in groups with similar management except for early ambulation. Group II — nonambulation; Group VI — Early ambulation.

tive balance of 19.4 Gm. with a difference of only 2.8 Gm. This difference between groups of 13.7 Gm. was also highly significant (P = 0.004). In both comparisons the groups receiving early ambulation (VI and XII) showed less of a difference in their nitrogen balance than the groups not receiving ambulation.

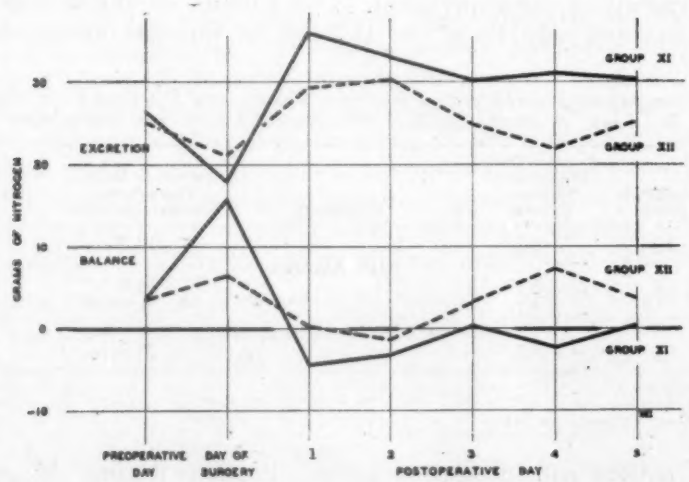

Fig. 3. — Preoperative average and postoperative daily nitrogen balance and excretion in groups with similar management except for early ambulation. Group XI — nonambulation; Group XII — early ambulation.

Since the nitrogen intakes of the compared groups were the same, this definite effect of early ambulation on nitrogen balance must be due to differences in nitrogen excretion. An analysis of the data revealed that group VI excreted an average of 9.8 Gm. less than group II for the six-day period This difference was highly significant (P = 0.005). Similarly, group XII excreted 16.9 Gm. less than group XI (P = 0.006) for the six-day period.

As can be seen in figure 2, the nitrogen excretion of groups II and VI fell on the day of operation and gradually returned toward the preoperative level as nitrogen intake was increased. On the other hand, the nitrogen excretion did not follow quite the same pattern when the patients were fed by tube diets high in protein (fig. 3). The nitrogen excretion of the patients in group XI fell on the day of operation and then remained well above the preoperative level for the rest of the period; group XII, however, remained above the preoperative excretion level on the first and second postoperative days and then returned to the preoperative level thereafter. It appears that

TABLE 4. — *Computation of Differences Between Preoperative and Postoperative Nitrogen Balance and Nitrogen Excretion (in Grams) and the Comparison of Group Differences.*

Group Number	Number of Patients	Total Calculated 6 Day Preoperative Nitrogen Balance	Total 6-Day Postoperative Nitrogen Balance	D	P	Total Calculated 6 Day Preoperative Nitrogen Excretion	Total 6 Day Postoperative Nitrogen Excretion	D	P
II*	10	—1.4	—31.1	—29.7		79.9	76.1	—3.8	
vs					0.005				0.005
VI[1]	8	—3.0	—22.8	—19.8		83.5	69.9	—13.6	
XI*	5‡	+22.4	+5.9	—16.5		159.1	178.2	+19.1	
vs					0.004				0.006
XII†	5	+22.2	+19.4	—2.8		150.2	152.4	+2.2	

1 Two patients omitted; see text.
* Nonambulation.
† Early ambulation.

the patients of group XI (nonambulated) were less able to handle this large amount of nitrogen postoperatively than the patients of group XII (ambulated).

Early Ambulation and Weight Loss. — Each patient was weighed on the morning of operation and again on the sixth or occasionally on the seventh postoperative day. Since the patients of group II were not allowed out of bed until the tenth postoperative day and were weighed on that day, this group could not be used for comparative changes in weight. Group IV, however, was identical to group II except that spinal anesthesia was used instead of ether.

Despite the relatively short period (six to seven days) over which these observations extend, it is believed that these data are significant. All changes in weight were standardized to the sixth postoperative day. Some of the weight loss was due to reduction in body mass and some to shifts in fluid balance. Since the patients had been eating their full quoto of food for two days prior to their last recorded weight and were in relatively good condition at that time, it is believed that a normal hydration of the body had been reestablished.

The patients of group IV (nonambulated) lost an average of 2.02 Kg. from the day of operation to the sixth postoperative day. The patients of group VI (ambulated) lost an average of only 0.78 Kg. over the same period. This difference in favor of the ambulated group (VI) was statistically significant ($P = 0.002$). Although group XI (nonambulated) lost an average of 1.82 Kg. from the day of operation to the sixth postoperative day while group XII (ambulated) lost only 0.08 Kg., the difference was not significant. Comparison of the two ambulated with the two nonambulated groups was not justified because of heterogeneity between pairs of groups receiving, or not receiving, early ambulation. Therefore, an analysis of variance was applied to the two groups which were not ambulated (IV and XI) and the

two groups which were ambulated (VI and XII). The analysis showed that early ambulation very probably (P = 0.045) decreased the postoperative weight loss.

Early Ambulation and Cardiovascular, Respiratory and Muscular Efficiency. — Numerous tests of cardiovascular efficiency have been applied as tests of "physical fitness," although in many studies the results obtained on different tests have indicated poor intercorrelations. Nevertheless, the use of the same test on the same patient permits a comparison of preoperative and postoperative performance. The tests used in this study were restricted to those which patients convalescing from surgical procedures could perform. With the exception of the tilt-table test, they have been described in detail elsewhere.[11] A complete analysis of the method used for scoring performance of the tilt-table is in preparation for publication.

Tilt-Table Test. — This was utilized to obtain a measure of the impairment in circulatory efficiency which may occur after operation and bed rest. Normally the compensatory mechanisms by which the effects of gravity on the circulation are offset are remarkably efficient. However, if any of the factors fail, the tendency for the blood to pool in the extremities occurs more readily. MacLean and his associates[20] have shown that patients kept at bed rest for long periods may have syncope when they again stand upright. They suggested that this can be avoided by having the patients rest in a semirecumbent position for several days before being allowed to stand.

The test was conducted on the patients in an air-conditioned room maintained at a constant environmental temperature and humidity (23.3 C. dry bulb and 40 per cent relative humidity). It was conducted twice preoperatively and again on the second, fourth and, if necessary, sixth or later postoperative day under standardized conditions. After resting in bed for at least one hour following breakfast, the patient was placed in a horizontal position on the tilt-table for five to six minutes. Then the pulse rate and blood pressure were taken until two successive pulse readings varied by no more than two beats per minute and blood pressures by no more than 2 mm. of mercury. The patient was then tilted passively from the horizontal to an angle of 68 degrees with the head up. The body was supported for a period of twenty minutes on a perineal support (bicycle seat), with a broad strap drawn lightly across the chest but without any support from a foot rest. Blood pressures and pulse rates were recorded at one minute intervals during the twenty minutes' passive tilt. The postoperative score for the second and fourth days was expressed as a percentage of the average preoperative score.

A comparison of the results on the ambulated and nonambulated patients (table 5) revealed that the patients of group VI (ambulation) showed less impairment postoperatively (P = 0.030) than the patients of group II (no ambulation). However, no difference could be demonstrated between group XII and group XI, although the average value obtained for group XII (ambulated) was better than that for group XI.

An analysis of variance was applied to the data of the two groups which were not ambulated (II and XI) and the data of the two groups which were ambulated (VI and XII). The analysis showed that early ambulation very probably (P = 0.046) reduced the impairment of the cardiovascular system as measured by this test.

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20. Berry, M. R., Jr.; Horton, B. T., and MacLean, A. R.: The Importance of Studying the Postural Responses of the Blood Pressure and the Heart Rate, with a Note on the Method of Taking the Blood Pressure in the Erect Posture, M. Clin. North America 24:1095, 1940. MacLean, A. R.; Craig, W. Mck., and Allen, E. V.: Application of Postural Physiologic Principles in Neurosurgery, Proc. Staff Meet., Mayo Clin. 16:369, 1941.

It should be noted that one patient who received early ambulation exhibited syncope both times preoperatively. This patient did not have syncope and performed well both times postoperatively.

In general, the groups which received early ambulation showed little impairment or had improved postoperative scores; the groups which did not receive early ambulation showed greater postoperative impairment.

Push-Up Test. — This simple weight lifting apparatus[21] (fig. 1), constructed on a frame which fits over the bed, was designed to permit a standardized

TABLE 5. — *Comparison of the Postoperative Tilt-Table Performance as a Percentage of the Preoperative Performance* $\left(\frac{\text{Preoperative Performance}}{\text{Postoperative Performance}} \times 100\right)$ *in Groups Subjected to Various Managements.*

Group Number	Number of Patients	Twenty Minute Tilt-Table Response	Probability
II*	4	50	
vs			
VI†	6	85	0.03
XI*	7	84	
vs			
XII†	5	103	Insignificant
II and XI	11	67	
vs			
VI and XII	11	94	0.046‡

* Nonambulation.
† Early ambulation.
‡ By analysis of variance.

amount of work to be performed by a patient while recumbent in bed and without placing a strain on the abdominal muscles. The patient was required to raise and lower a 20 pound weight with each arm a distance of 1 foot at a rate of thirty times per minute for two minutes. The apparatus was used either as a test for circulatory efficiency or as a form of exercise. Whether used as a test or as a form of exercise, it was applied three or four times preoperatively and again on the first and succeeding postoperative days.

TABLE 6. — *Push-Up Test: Difference Between Preoperative and Postoperative Increases in Pulse Rate After Test.**

Group Number	Number of Patients	First Postoperative Day 5-35 D	Sec. x 2 P	60-90 D	Sec. x 2 P	Second Postoperative Day 5-35 D	Sec. x 2 P	60-90 D	Sec. x 2 P
V†	6	+9	0.051	+8	0.020	+10	0.052	+4	Insign.
VI‡	6	—1	Insign.	—5	0.038	—1	Insign.	—3	Insign.
XII‡	4	—5	0.072	—5	<0.001	—4	0.084	—6	0.045
V vs VI	....	.....	0.006	.....	<0.001	.....	0.005	.....	0.038
V vs XII	....	.....	0.007	.....	<0.001	.....	0.005	.....	0.021

* Indicates that the increase postoperatively was greater than preoperatively for the corresponding time interval.
† Modified ambulation.
‡ Early ambulation.

Because this apparatus afforded a certain amount of exercise, its use was limited to the groups receiving early ambulation and to one group (V) which received a modified form of ambulation. The latter group (V) was similar to group II except that it received spinal anesthesia and the push-up, step-up and psychomotor tests. These patients were not permitted out of bed until the tenth postoperative day and were not given the step-up test until the eleventh postoperative day. The resting pulse rate was obtained

21. Designed and constructed by Prof. M. K. Fahnestock and Mr. George J. Oehmke, of the Department of Mechanical Engineering, University of Illinois, Urbana.

and, starting five seconds after the end of the test, the pulse rate was recorded at five second intervals for three minutes. Table 6 shows the results on three groups. The values represent the differences in pulse rate between the preoperative and postoperative increases which occurred five to thirty-five seconds and sixty to ninety seconds after the test.

The ambulated patients (group VI and XII) were either as good or better postoperatively as compared with their preoperative performance, whereas the patients who received modified ambulation (group V) were probably slightly impaired on only the first two postoperative days. Despite the raising and lowering of 40 pounds sixty times in two minutes, this test did not place too great a stress on the cardiovascular system of healthy young men convalescing from herniorrhaphy.

As mentioned, this apparatus provided an excellent form of exercise which can be given to a patient in the immediate postoperative days without danger to the wound. It may also be instrumental in giving relief from gas pains. Four patients who complained bitterly of gas pains on the first postoperative day and pleaded that they could not do this test were persuaded to try it. Not only did they complete the test but, in addition, remarked that they felt better immediately afterward. The relief from gas pains was striking.

Stair-Climbing Test. — This test required the patient to climb two flights of stairs (44 steps, 6⅞ inches each), in thirty-five seconds and then to sit down in a chair immediately afterward. Both preoperatively and postoperatively the patients were taken in a wheelchair to the foot of the stairs. The test was scored in the same manner as the push-up test.

In comparison with the preoperative performance, no definite impairment of circulatory efficiency was observed in the three groups that received this test — groups VI, XII and XIII (nonambulated, tube-fed basal calories plus 100 per cent) — on the second and third postoperative days. Obviously this test offered too mild a form of exercise to be of any value.

Step-Up Test. — This test was also applied preoperatively and postoperatively and was scored in the same manner as the push-up test. The patient was required to keep one foot continuously on a 9 inch step and raise the other foot from the floor to the step and return to the floor again at a rate of thirty per minute for three minutes. The test was not applied postoperatively until the seventh (group III) or eleventh day because of the possible deleterious effects on the wound.

The response to this test was studied on four groups of patients — groups II, II A (three older patients removed from group II) V and III (in addition to ambulation, this group received all factors which would conceivably have a favorable influence on convalescence — table 1). The only group which showed a definite postoperative impairment was group II A. This impairment appeared when the patients were first tested on the eleventh postoperative day and disappeared on the twelfth day. Group III (ambulated) showed no impairment when first tested on the seventh postoperative day. The data indicate again the relatively slight depression of circulatory efficiency caused by herniorrhaphy.

Flarimeter Test. — This has been used for testing circulatory fitness.[22] The length of blow after exercise has been shown to decrease 18 per cent in subjects suffering from a cold.[23] The test was scored by the length of time the patient was able to maintain an expiratory pressure of 40 mm. of

22. Wells, P. V.: The Flarimeter, A Clinical Instrument for Testing Circulatory Fitness, Rev. Scientific Instruments 1:332, 1930.
23. Henry F.: Functional Tests: III. Some Effects of the Common Cold on Cardio-Respiratory Adjustments to Exercise and Cardiovascular Test Scores, Res. Quart. 13:317, 1942.

mercury. By inserting a metal tube with an orifice 1/64 inch in diameter and 1/4 inch long into the system for release of the air, the patient was compelled to maintain a continuous flow of air at constant pressure.

The results of this test should be considered suggestive, since only a few patients in each of the groups (II, II A, III, and V) were studied. The 3 older patients (group II A) were unable to maintain the pressure as long postoperatively, and 2 exhibited dizziness which was not apparent preoperatively. Three of the 4 patients of group V also exhibited dizziness postoperatively. The performance of the patients of groups II and III was unimpaired.

Vital Capacity. — This was determined on three groups of patients (II, III and V) by means of a Collins Spirometer. The test was first given postoperatively on the seventh day to group III and on the eleventh day to groups II and V. The postoperative values were the same as the preoperative values for all three groups. It is highly probable that these values would have been normal even earlier.

Early Ambulation and Strength of Hand Grip and Endurance Time. — The Smedley Hand Dynamometer was used to measure both the strength of hand grip and the endurance time. The highest of four trials given at thirty second intervals was accepted as the maximum grip, and the length of time the patient could maintain a grip equal to 40 per cent of the maximum was accepted as the endurance time. For the measurement of the postoperative endurance time the dynamometer was set at the same level as that used preoperatively. The tests were given on four days preoperatively and resumed on the first postoperative day.

There was no statistically significant postoperative deterioration for strength of hand grip or endurance time in any of the groups. Some patients showed slight impairment on the first postoperative day, but most showed no change.

Early Ambulation and Sedation. — Postoperatively the patients were given small doses of morphine (10 mg.) for pain when needed. Most patients, however, did not receive more than 30 mg. of morphine in twenty-four hours.

The amount of sedation required by the ambulated patients (groups VI and XII) and that required by the nonambulated patients (groups II and XI) was not significantly different on the day of operation. On the other hand, on the first postoperative day the patients of groups VI and XII required significantly ($P = 0.002$) less sedation than the patients of groups II and XI. Requests for sedation in all groups were markedly reduced thereafter.

Early Ambulation and Bowel Evacution. — Enemas were ordered routinely for the patients on the fourth or fifth postoperative day unless evacuation occurred before this. Only one patient of the nonambulated groups II and XI had a bowel movement without the aid of an enema. On the other hand, only two patients in the ambulated groups VI and XII received enemas; all the others had normal bowel movements without the aid of an enema. It was obvious from the records that the ambulated patients, permitted use of the toilet, had earlier bowel movements without the aid of enemas.

Early Ambulation and Appetite. — The ambulated patients ate their food seated at a table and, by observation, appeared to have a better appetite than the nonambulated patients. They ate all of their food with less urging from the dietician. This has also been noted by Leithauser.[24]

24. Leithauser, D. J.: Early Ambulation and Related Procedures in Surgical Management, Springfield, Ill., Charles Thomas, Publisher, 1946.

Early Ambulation and Recurrence of Hernia. — A total of 80 patients submitted to herniorrhaphy. Some of these include groups not discussed in this report. Nineteen patients received early ambulation and an additional 7 (group V) received modified ambulation. Two and one-half to three and one-half years have elapsed since these patients submitted to operation. It has been impossible to recall all of them for examination and questioning, for some are still in the armed services overseas and others have moved, leaving no forwarding address. Nevertheless, 51 patients have responded, 34 nonambulated, 12 with early ambulation and 5 with modified ambulation. None of the early ambulation or modified ambulation patients examined has had a recurrence, whereas 2 of the nonambulated patients have had a recurrence. One of these joined the Merchant Marine within three months of discharge from the hospital. He engaged in strenuous physical activity which resulted in an early recurrence of the hernia. Since the number of patients examined for recurrence at this time is small, it may merely be stated that recurrence was no greater in patients receiving early ambulation than in nonambulated patients.

Comment

The deconditioning brought about by postoperative confinement to bed places the patient at a definite disadvantage and is not at all necessary. This deconditioning can be safely counteracted by instituting a regimen of early ambulation.

The explanation of the favorable effect of early ambulation in decreasing postoperative nitrogen excretion and weight loss is not readily apparent. In all probability the maintenance of good circulation and tone in the muscles, as well as good gastric tone and motility, plays an important role.

Conclusions

The data obtained justify the following conclusions:

1. Early ambulation did not decrease the observed impairment of the liver, except in one comparison.
2. A negative nitrogen balance occurred in patients convalescing from herniorrhaphy and fed submaintenance calories during the first few postoperative days. The extent of this negative nitrogen balance was reduced by instituting a program of early ambulation.
3. A positive nitrogen balance was maintained in patients convalescing from herniorrhaphy and tube fed a diet high in protein. The extent of this positive balance was increased by instituting a program of early ambulation.
4. It was shown that the nitrogen intake of the compared groups was the same preoperatively and postoperatively and that the favorable effect of early ambulation on the nitrogen balance was due to a decreased nitrogen excretion during the postoperative period in the ambulated groups.
5. Early ambulation reduced the postoperative weight loss.
6. As measured by performance on the tilt-table, the ambulated patients showed little impairment or had improved scores postoperatively; the nonambulated patients showed postoperative impairment.
7. As measured by the push-up test, the ambulated patients performed as well or better postoperatively than preoperatively. The patients of one group (V) who received modified form of ambulation were slightly impaired only for the first two postoperative days. Exercise by use of this type of apparatus may provide relief from gas pains during the early postoperative period.

8. A stair-climbing test revealed no definite impairment in circulatory efficiency when applied to three groups of patients on the second and third postoperative days.

9. Only the 3 older patients showed a significant impairment of the cardiovascular system as measured by the step-up test. This occurred on the eleventh postoperative day and disappeared on the twelfth day.

10. The results of the flarimeter test were suggestive, indicating that a more detailed study is required.

11. Vital capacity was unchanged on the seventh (group III) and eleventh postoperative days (group II and V). It is probable that these values would have been normal even earlier.

12. No significant changes were observed in strength of hand grip and endurance time.

13. Patients receiving early ambulation required significantly less sedation than nonambulated patients on the first postoperative day.

14. Patients receiving early ambulation had earlier bowel movements without the aid of enemas than nonambulated patients.

15. Patients receiving early ambulation appeared to have a better appetite than nonambulated patients and ate their required amount of food with less urging from the dietitian.

16. No recurrences of the hernia were noted 2½ to 3½ years after operation in the 17 reexamined patients of 26 who received early or modified ambulation. Two recurrences of the hernia were noted in the 34 reexamined patients of 54 who were not ambulated.

We gratefully acknowledge the valuable assistance of Mr. Edward Eckert in the tabluation and analysis of the data and of Miss Jean Miller and Miss Erma Schumacher in the chemical analysis of biologic specimens.

Discussion

Dr. Arthur C. Jones (Portland, Ore.). It is a privilege to thank the authors of this very interesting paper for a significant contribution. It offers exact information of the type which we of the Congress have wanted for a long time.

I am heartily pleased to see the statistical analyses, showing clearly how the findings have been subjected to careful study, because it gives us who are meeting these same problems in hospitals and medical schools more material with which to meet any objections and give instruction in early ambulation.

The term "ambulation" has been stretched just a little. Ambulation really means walking, and I might reasonably advocate a slightly different term. Perhaps it is something of a diversion of the meaning to speak of push-up exercises for the arms as representing ambulation.

I should like to emphasize the psychic factors which have to do with appetite and also with outlook. In a study of this sort, which is concerned with physiology as such, a careful worker would have to disregard, or at least minimize, these factors, but I am sure that those of you who have had to do with early postoperative exercise have appreciated fully the very great importance of the effect on the patient's psyche. Change of outlook and a feeling of hopefulness are most remarkable stimuli to the average surgical patient.

The avoidance of deconditioning and of "hospitalitis," as we sometimes call it, is very clearly brought out by studies such as this. This is rehabilitation of the most practical sort. It is universal because it is part of the means at the disposal of the physiatrist but of the surgeon, the general practitioner, the internist and anyone who is interested in medicine.

The physiatrists can foster and help with the details of early ambulation. It should be one of our goals to help to standardize the practical phases of postoperative exercise and early ambulation and to insist in our various institutions on a real observation of what constitutes early ambulation as it has been presented here.

MEDICAL NEWS

American Board of Physical Medicine

The next examinations for the American Board of Physical Medicine will be held in Atlantic City, June 4 and 5, 1949. The final date for filing application is March 15. The Secretary is Dr. R. L. Bennett, Georgia Warm Springs Foundation, Warm Springs, Ga.

Sessions on Physical Medicine at Atlantic City

The Council on Scientific Assembly of the American Medical Association has allotted two sessions in the Section on Miscellaneous Topics at the 1949 Annual Session in Atlantic City to Physical Medicine and has appointed Dr. Howard A. Rusk, New York, to serve as Chairman, and Dr. Frank H. Krusen, Rochester, Minn., as Secretary.

Study Group on Hydrotherapy

For a long time it has been the desire of physiatrists especially interested in hydrotherapy to organize in order to promote and to develop this important branch of physical medicine.

A group met at a luncheon meeting during this year's annual meeting of the American Congress of Physical Medicine in Washington, D. C.

After an interesting discussion a committee was elected and instructed to prepare the ground for the next meeting in Cincinnati in 1949.

Members of the committee are: Dr. H. J. Behrend, New York, Chairman; Dr. S. A. Warshaw, Brooklyn, Secretary; Dr. R. L. Bennett, Warm Springs, Ga.; Dr. K. G. Hansson, New York; Dr. Richard Kovács, New York; Dr. W. S. McClellan, Saratoga Springs; Dr. W. D. Paul, Iowa City.

All those interested in hydrotherapy are invited to communicate with the chairman.

Section on Physical Medicine, Southern Medical Association

The Section on Physical Medicine of the Southern Medical Association at its 42nd annual meeting held in Miami, Fla., elected the following officers:

Chairman, George D. Wilson, Asheville, N. C.

Vice-Chairman, Walter J. Lee, Richmond, Va.

Secretary, Col. E. M. Smith, MC, Washington, D. C.

The guest speaker or essayist was Dr. Temple Fay, Director of the Neurological Rehabilitation Institute, Chestnut Hill, Pa. Dr. Fay presented methods of evaluation for cerebral palsy cases that can be rehabilitated. Dr. Fay presented a newer, revised and much needed classification of cerebral palsy based on neuroanatomy. A committee composed of Drs. Ben Boynton, Dallas, Tex.; F. Schwartz, Birmingham, Ala., and George D. Wilson, Asheville, N. C., was voted to promote Inter-American relationship on Physical Medicine with the Southern Medical Association.

The Seventh International Congress on Rheumatic Diseases

The Seventh International Congress on Rheumatic Diseases will be held in New York City, May 30 through June 3, 1949 under the sponsorship of the International League against Rheumatism. Hosts will be the officers and the 400 members of the American Rheumatism Association, assisted by the New York Rheumatism Association.

The Congress will be the first International Congress on Rheumatic Diseases to be held in the United States. It will provide the first opportunity since the war for physicians and scientists, from Europe and North and South America, to meet together to present and discuss new developments concerning the rheumatic diseases, which constitute one of the greatest causes of world wide invalidity. The Congress is being held with the official sanction of the United States Government whose State Department will cooperate in the issuance of official invitations to various governments and Rheumatism Associations. The invited guests will be the members of the International League, the European League and Pan American League against Rheumatism with their constituent organizations, the Canadian Rheumatism Association, the British Empire Rheumatism Council, the Heberden Society of London, and the ten state or civic Rheumatism Societies affiliated with the American Rheumatism Association and certain other individuals.

Program: Seven plenary sessions will be held at the Hotel Waldorf-Astoria, Headquarters of the Congress, at which sessions will be presented discussions of certain fundamental and clinical topics related to rheumatology. Such fundamental subjects as histochemical and biophysical studies on connective tissue, physiology of joints and muscles, pathology of rheumatic diseases, the influences of the nervous and endocrine systems on the basic phenomena of articular diseases, hyaluronic acid and hyaluronidase in relationship to rheumatic diseases. Five one hour panel discussions on various controversial topics will be held under the leadership of authorities in their respective fields.

ARCHIVES of PHYSICAL MEDICINE

OFFICIAL PUBLICATION AMERICAN CONGRESS OF PHYSICAL MEDICINE

.·. EDITORIALS .·.

BEST WISHES FOR A MERRY CHRISTMAS AND A HAPPY NEW YEAR

The officers of The American Congress of Physical Medicine send Christmas Greetings to the members and friends of our organization and hope that everyone experiences a happy and enjoyable holiday season. We are grateful for your loyalty and support during the year nineteen-hundred-forty-eight and we acknowledge with pride the achievements in physical medicine made possible by your efforts. We trust that during the New Year, beginning January 1, 1949, you will receive continued pleasure and satisfaction in supporting the democratic principles of our nation and our profession, keeping foremost in mind the sanctity of the sacred rights of the individual, the virtues of cooperation and the power of unity of purpose in providing the best possible medical care for those who seek our guidance and assistance.

O. Leonard Huddleston, M.D.,
President,
American Congress of Physical Medicine.

INFRA-RED RADIATION

Radiant heat from the infra-red portion of the electromagnetic spectrum is probably the most extensively used form of physical therapy. Sufferers of many diseases and disorders have known with and without the benefit of the medical profession its possibilities of relieving symptoms. Other means of producing local heat are available and effective and include all the various forms of hydrotherapy and the high frequency alternating currents. Recently a great deal of interest and much scientific work has been directed toward the use of the diathermy machines as a means of applying heat. During the past few years the ARCHIVES OF PHYSICAL MEDICINE has been an important source of original information on the physical phenomena, physiologic effects and clinical application of medical diathermy; note the three outstanding articles in this issue of the ARCHIVES This essential and timely emphasis on the high frequency currents should not detract from the value of the radiant type of heating or lessen further efforts to make its new use still more effective. Many questions arise as to more specific technic; the variations in the penetration of the various parts of the infra-red spectrum; the effect on blood flow; the possible chemical changes, particularly the production of histamine or histamine-like substances; the changes in muscle contractions, to cite only a few of the problems.

The length of time of a local treatment with infra-red lamps has been prescribed from a few minutes to several hours. The maximum increase in temperature of the skin has been found after an exposure of twenty minutes and the temperature does not level off until after about thirty minutes. More

recently Evans and Mendelssohn[1] studied the effect of the radiation from a heat cradle. They maintain a heat cradle supplies three sources of heat, namely (1) the filaments of the lamp, (2) the glass envelops of the bulbs and (3) the metal background of the cradle. They observed that the filament of the lamp and the glass of the bulb reach their maximum energy flow within about a minute of turning on of the cradle but the metal background does not reach its maximum power for an hour. Quoting from their measurements which were done by what they term a thermo-radiometer they state "the metal background radiates from each square centimeter of its surface only about 1-1000 of the energy emitted by one square centimeter of lamp filament, however, the metal background is so extensive that it occupies a considerable part of the radiating hemisphere" and "that a square centimeter of skin in the center of the cradle will receive about 0.5 pyron (their term for the unit of intensity of radiation) from sources (1) and (2) and about one pyron from source (3). In other words, a patient put under a cradle will receive three times as much radiation after an hour as he did at the beginning of the treatment."

The distance that a lamp should be from the part has been a source of considerable confusion. An excellent study done by Elkins and Sheard[2] demonstrated that most of the luminous types of heat lamps could be applied at distances of 14 to 18 inches. Obviously, in certain diseases, greater distances must be prescribed. They also noted that the iron resistant type of lamp produced considerable pain at these distances even though the skin temperature was not raised to the level obtained with the tungsten filament lamps.

Sheets, towels or other materials are occasionally placed over the part being treated. Patients, too, when administering treatment in their homes often keep on their clothes as a matter of convenience. Experiments have shown[3] that various textile materials such as blankets, towels, cotton and linen sheets transmit 20 to 30 per cent of the long infra-red rays and 30 to 40 per cent of the short infra-red rays. The authors state that "it must not be assumed that the patient will only receive, say 25 per cent of the energy incident on the upper surface of the blanket. In addition, the blanket will gradually warm up to a temperature depending on the particular circumstances, and will transmit energy, not only by secondary radiation, but also by conduction, both by direct contact and across air pockets trapped between the blanket and the skin."

The importance of the type of lamp for different areas under treatment has been investigated by a few workers in this country and abroad. The most recent article from the University of Iowa group[4] made observations on the coverage patterns of infra-red generators of various design and wattage. They concluded that when the whole body is to be treated a lamp with a very broad coverage pattern is to be used. When a small area is to be treated a lamp with a narrow beam source of infra-red radiation is most satisfactory which they found was produced by a generator of 300 watt carborundum type mounted in a reflector or a lamp with a 500 watt dull glowing ceramic source mounted in a polished reflector. They also found that lamps of a 1000 watt tungsten and 1000 watt carborundum source mounted in reflectors could be used for dual purpose coverage. In this ar-

1. Evans, D. S., and Mendelssohn, K.: Physical Basis of Radiant Heat Therapy, Proc. Roy. Soc. Med. 38:573 (Aug.) 1945.
2. Elkins, E. C., and Sheard, C.: Effect of Infra-Red Irradiation on Cutaneous Temperatures, Arch. Phys. Therapy 21:476 (Aug.) 1941.
3. Evans, D. S., and Mendelssohn, K.: Clinical Application of Heat, Brit. Med. Bull. 3:143, 1945.
4. Rovner, L.; Paul, W. D., and Hines, H. M.: Survey Method for Radiation Coverage Patterns of Infra-Red Generators, Arch. Phys. Med. 27:273 (May) 1947.

ticle they promised further studies which should make possible dosage prescription for coverage area for this type of therapy. Such work is urgently needed.

The color of the glass used in the bulb types of lamps has been the source of misinformation for some physicians. The glass of the bulb lamp absorbs about 3 per cent of the energy and an additional 8 per cent is lost by reflection. These amounts are not entirely lost for this energy actually aids in warming the glass which then radiates energy in the far infra-red field. When a red glass bulb type of lamp is used the radiation is in the infra-red part of the spectrum from 7000 Å to 20,000 Å[5] with the heated glass itself radiating in the very long wave length infrared. The red glass bulb actually radiates less of the infra-red rays than the clear glass but this is more theoretical than practical. The advantage of the colored glass is that there is less light glare.

The penetration of the different infra-red rays has received attention for many years. Infra-red rays when they are directed to the body may be transmitted unchanged, reflected from its surface or absorbed and converted back into heat. The penetration of these infra-red rays depend on their wavelength. The selection of a lamp providing a preponderance of various sections of this part of the spectrum is considered important in the treatment of diseases. Physiatrists have known that the short infra-red rays are more penetrating than the long infra-red rays. It has been shown that at about 11,000 Å a maximum amount of energy is absorbed, whereas with wavelengths longer than 16,000 Å very little of the energy is transmitted, so that radiation of the long infra-red waves is either reflected or only a slight amount is absorbed in the outer layers of the skin. A generator with a relatively high temperature, an example is the tungsten filament lamp, provides rays with the greatest penetration. Measurements have shown that approximately 11 per cent of the radiation from this type of lamp passes through the corium of the ordinary white skin and enters the deeper layer of muscle and fat. The iron resistant type of lamp with a lower temperature provides the infra-red rays of longer wavelengths which will be absorbed chiefly in the outer layers of the skin, namely, the stratum corneum and stratum lucidum. The carbon filament bulb with a temperature less than the tungsten lamp but greater than the iron resistant type furnishes rays which will have less penetration into the muscle and fat but would be absorbed in the corium.

Vasodilatation is considered one of the most valuable effects of local heat therapy. Vasodilatation with a resulting increased blood flow is thought to be beneficial in hurrying up the resolution of an inflammatory process in the tissues involved. A recent study on blood flow in the human forearm[6] was made on the effect of external temperatures ranging from 13 to 45 C. From 37 to 42.5 C. the flow rose to a maximum in periods which shortened as external temperature rose. A steady decrease followed this peak. At 45 C. the blood flow reached the maximum in about thirty minutes and remained at this level. It was concluded that the deep muscle temperature was influenced by the environmental temperature, the length of time of exposure, the rate of blood flow, the body temperature and the local metabolic rate. This agrees with the earlier work which showed that maximum vasodilatation occurred when the local temperature of the part being treated

5. Anderson, W. T.: Physical Aspects of Infra-Red Radiant Energy in Therapy, Arch. Phys. Therapy 17:699 (Nov.) 1937.
6. Barcroft, H., and Edholm, E. G.: Temperature and Blood Flow in Human Forearm, J. Physiol. 104:366, 1946.

was 40 C.[7] A most interesting report made at the 1948 annual meeting of the American Congress of Physical Medicine by Hollander and Horvath showed that the application of a baker over the extremities for thirty minutes resulted in a rise of the temperature inside the knee joint of as much as 4.4 F. They state that[8] "generally this increase was not as great as this peak value, the usual increment being about 2 F." Of importance is their observation that hot packs applied to the knee usually resulted in a decrease of the intra-articular temperature whereas cold packs increased the temperature within the joint.

An increase in blood flow is materially affected by the condition of the vascular system of the extremities particularly of the lower extremities. One of several noteworthy studies of the circulation in peripheral vascular diseases by de Takats[9] shows that where the external temperature is between 85 and 100 F. the blood flow is not accelerated more than 1.94 to 3.06 a minute per hundred grams of tissue. When definite impairment exists causing ischemia of tissues the application of external temperatures exceeding these figures is definitely dangerous and is contraindicated. Many patients treated by radiant heat for arthritis, fractures, hemiplegias and other disorders of the extremities are in the older age groups and whose peripheral circulation must frequently be deficient to varying degrees. Does the use of the ordinary heat lamp actually increase blood flow for these patients?

The increase in vasodilatation under infra-red radiation is a defense mechanism against overheating the skin. Exposure to infra-red radiation is not confined to the local area exposed since the heat that is applied is removed by an intact circulatory system to the other parts of the body, and unless the body is enclosed so as to prevent this loss of heat by evaporation and sweating the body temperature remains normal. When the circulation to the local part is impaired or the energy applied is in excess of that which can be removed promptly, the skin is overheated and a burn results. Under standard conditions and in normal individuals the margin of safety is sufficiently great so that burns do not result but where pathologic conditions exist such as in peripheral vascular disorders, in scar tissue or where the circulation is diminished, this margin of safety may be small.

Other studies and investigations — response of sweat glands; value of various reflectors of the lamps; relaxation effect which includes such works as that of Denkman in her master thesis showing that twenty minutes of radiation produced a shortening of the latent and contraction periods of muscular activity, that of the Russian Vassilevsky showing that heat irradiation caused changes in the chronaxia, the absolute refractory phase and the velocity of the muscle contraction and the report of Benson's comparing the relaxation effect of moist heat, infra-red radiation and diathermy; alterations in cardiac output; effect of heat on the blood volume and circulation; changes in the temperature of the skin as compared to the muscle when external heat is applied — have all been of inestimable value in advancing the knowledge of local heat treatments. The medical profession has been helped in the care of their patients with such investigations. However, more research is still needed. Such studies should surely stimulate the physiatrists, physiologists and physicists in the development of better infra-red lamps, more accurate instructions as to the quantitative administration and further information on optimal physiologic possibilities of this type of therapy.

7. Goldschmidt, S., and Light, A. B.: The Effect of Local Temperature Upon the Peripheral Circulation and Metabolism of Tissues Revealed by the Gaseous Content of Venous Blood, Am. J. Physiol. 73:146 (June) 1925.
8. Hollander, J., and Horvath, S.: Personal communication.
9. de Takats, G., and Miller, D. S.: Blood Flow in Peripheral Vascular Diseases, War Med. 8:429 (May) 1942.

BOOK REVIEWS

TECHNIC OF TREATMENT FOR THE CEREBRAL PALSY CHILD. By *Paula F. Egel,* Cerebral Palsy Director, Children's Hospital, Buffalo, New York. Introduction by *Winthrop M. Phelps,* M.D., Medical Director, Children's Rehabilitation Institute, Baltimore, Maryland. Appendix by *Moir P. Tanner,* F.A.C.H.A., Superintendent, Children's Hospital, Buffalo, New York. Drawings by *Dorothea Mintline.* Cloth. Price, $3.50. Pp. 203 with 49 illustrations. The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Missouri, 1948.

This book presents in a concise, practical manner the accepted technics for the treatment of the various types of cerebral palsy as prescribed by Dr. Winthrop M. Phelps. In the initial part of the book, the author points out the necessity for accurate classification of the type of cerebral palsy, and she outlines various tests for the total evaluation of the patient that are prerequisite to treatment. The large portion of the text is an adequate discussion of the various modalities or phases of treatment used exclusively for cerebral palsy condition, and the discussion is thoroughly supplemented with line drawings and photographs. The modalities dealt with are: massage, passive motion, assisted active motion, active motion, resisted motion, conditioned motion, automatic or confused motion, combined motion, rest, relaxation, motion from relaxed positions, balance, reciprocation, reach and grasp, and skills. Appended to the text the author has included a list of apparatus and equipment that is essential for the proper handling and treatment of patients with cerebral palsy.

This book will prove to be of interest and value to those physicians and technicians interested in the treatment of cerebral palsy.

HANDBOOK OF ORTHOPEDIC SURGERY. By *Alfred Rives Shands, Jr.,* B.A., M.D., Medical Director of the Alfred I. du Pont Institute of the Nemours Foundation, Wilmington, Delaware; Visiting Professor of Orthopedic Surgery, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania; in collaboration with *Richard Beverly Raney,* B.A., M.D., Associate in Orthopedic Surgery, Duke University School of Medicine; Lecturer in Orthopedic Surgery, University of North Carolina School of Medicine. Third edition. Illustrated by Jack Bonacker Wilson. Pp. 574. Cloth. Price, $6.00. The C. V. Mosby Company, 3207 Washington Boulevard, St. Louis 3, Missouri, 1948.

This is the third edition of a concise textbook of orthopedic surgery in which the authors have included only the fundamental facts and principles of this specialized field of medicine. Because of its fundamental nature, the handbook has become increasingly popular as a teaching text for those students who require a knowledge of the general principles of orthopedic surgery.

The text is easy to read and understand, and it is adequately illustrated with artist's drawings. In addition to the brief, but adequate discussion of the various diseases and conditions encountered in this field, the book contains a bibliography which covers important articles written prior to February, 1948.

In this edition there have been minimal essential changes made in the text. Many parts of the book have been rephrased, a few illustrations have been added, the new advances in diagnosis and treatment are noted, and the bibliography has been brought up to date.

This book is recommended as an excellent short textbook on the fundamentals of orthopedic surgery. It will prove to be of value to the general practitioner, medical student, nurse, physical therapist and oocupational therapist.

FIELDING H. GARRISON. A BIOGRAPHY. By *Solomon R. Kagan,* M.D. Fabrikoid. Price, $4.00. Pp. 104. Medico-Historical Press, 40 Harrison Avenue, Boston 11, Mass., 1948.

Fielding H. Garrison was a great medical bibliographer, biographer and historian. He aided the advancement of medical history not only through his publications but also by his lectures on medical history and by inspiring young authors to do research work in this field. In his life he acted generously as a guide and adviser to research workers, authors and editors. Garrison was a cultivated man of letters and a brilliant correspondent. For a period of thirty years he had an extensive correspondence with personal friends and men of science, art and literature scattered over all the world. The author, a distinguished historian himself, has published in 1938, three years after Garrison's death, a volume "Life and Letters of Fielding H. Garrison." The present volume adds considerably to the biographical material in the earlier volume. It includes a number of Garrison's new letters, some new photographs of Garrison's family and associates. It divides Garrison's life into three main periods: childhood and education (1870-1890); career at the Library of the Surgeon General's Office in Washington, D. C., including his service in Manila, P. I. (1891-1929); and finally his closing years in Baltimore at the Welch Medical Library (1930-1935). It should make informative and fascinating reading for those interested to know more about the life and work of an outstanding American medical bibliographer and historian. humanitarian, lover of science, music and the arts

and a leader in his chosen field. Garrison was buried with full military honors at Arlington National Cemetery and in 1938, the American Association of the History of Medicine at its fourteenth annual meeting held in Atlantic City on May 2nd, 1938, had established the Fielding H. Garrison Lecture to honor the outstanding American medical historian.

ILLUSTRATIONS OF REGIONAL ANATOMY. By *E. B. Jamieson,* M.D., Senior Demonstrator and Lecturer Emeritus, Anatomy Department, University, Edinburgh. Seventh edition. Paper. 320 plates. Price, $20.00. The Williams & Wilkins Company, Mt. Royal and Guilford Avenues, Baltimore 2, Md., 1947.

This latest edition of anatomical illustrations represents 14 years of development and improvement, particularly the addition of color to the majority of the plates. There are now over 300 plates compiled in seven loose-leaf sections covering the entire body. This arrangement allows the student to remove several related pages for comparison and for use at the dissection table. The paper is of high quality, the colors brilliant and well chosen for contrast and the labeling usually sufficiently distinct. The illustrations are in part diagrammatic, particularly those of the central nervous system where function is in part indicated. Other plates are drawings from dissected specimens. There has been careful selection of material for the purpose of emphasizing important relationships so that they may be used in conjunction with lectures as well as for reference alone. This publication is highly recommended to students of anatomy and as a convenient reference atlas for physicians and surgeons.

FEVER AND THE REGULATION OF BODY TEMPERATURE. By *Eugene F. DuBois,* M.D., Professor of Physiology, Cornell University Medical College, Medical Director, Russell Sage Institute of Pathology. Fabrikoid. Price, $2.00. Pp. 68. Charles C Thomas, 301 East Lawrence Ave., 1948.

This is a comprehensive presentation by an outstanding physiologist on the present day knowledge on the factors relative to one of the most dramatic manifestations of disease, fever. It starts out with the statement that "there is no one normal temperature but instead a fairly wide zone that shifts up and down with the time of day and with other factors. In the second place no one quite understands what we mean by 'body temperature' and no one can measure the average temperature of the human body." It discusses in rotation: thermal balance, the physical laws of heat loss, the effect of exercise, the functions of the skin in temperature regulation, temperature gradients, chills, sweating and chemical regulation. Subsequent sections deal with exposure to cold and heat, fever therapy and finally fever in disease, the fall in body temperature, basal and total metabolism in fever, specific dynamic action of food in fever, the need for water, management of fever patients, the thermoregulatory apparatus. The practical and up to date contents of this excellent monograph should be of interest to all physicians and especially valuable to physiatrists carrying on fever therapy.

THERAPY THROUGH INTERVIEW. By *Stanley G. Law,* M.D., Minnesota Psychiatric Institute. Cloth. Price, $4.50. Pp. 313. McGraw-Hill Book Company, Inc. 330 West 42nd St., New York 18, N. Y., 1948

This book was written to aid physicians in general practice who desire to use psychotherapy in an effort to treat the whole patient. The book consists largely of fictional interviews with patients, each case being a prototype of many actual patients which Dr. Law has treated. The book, in a sense, is highly specialized, giving examples of how patients may be treated, but does not discuss very thoroughly the mechanisms through which the symptoms are developed. The principles of conflict, repression, sublimation and positive transference are not emphasized. The fact that the patient often needs the therapist as a crutch which he has no desire to relinquish is an important one. Also the book would be improved by enumerating danger signals and what is, and what is not, within the realm of the general practitioner to treat. Much harm can be done by the neophyte if he tries to take on too much.

The book has many excellent examples of therapy through interview, and will serve well the physician who has already learned the basic principles of psychiatry and psychotherapy.

HEALTH INSTRUCTION YEAR BOOK, 1947. Compiled by *Oliver E. Byrd,* Ed.D., M.D., F.A.P.H.A., Professor of Health Education, and Director, Department of Hygiene, School of Education, Stanford University, Calif. Foreword by *Claire E. Turner,* D.Sc., Dr. P.H. Cloth. Price, $3.00. Pp. 325. Stanford University Press, Stanford University, Calif.; Oxford University Press, Amen House, Warwick Sq., London, E. C. 4, 1947.

Not less than 323 articles on public health, selected from 1,672 articles read by the editor are reported on in the 1947 Health Instruction Year Book. They are organized in 21 chapters, each preceded by lucid and well readable explanatory comments. The selection of material is excellent and its presentation is concise. Among the material of special interest to physical medicine are exercise and body mechanics, fatigue and rest, health and the physical environment. A full bibliography, alphabetical lists of sources, author and subject index makes the location of all references easy. This is a most comprehensive and satisfying basic reference to recent health literature.

A-B-C's OF SULFONAMIDE AND ANTIBIOTIC THERAPY. By *Perrin H. Long,* M.D., F.R.C.P., Professor of Preventive Medicine, The Johns Hopkins University School of Medicine; Physician, The Johns Hopkins Hospital. Cloth. Price, $3.50. Pp. 231. W. B. Saunders Company. West Washington Square, Philadelphia 5, 1948.

This little book is based on many years' experience in the use of sulfonamides and antibiotics. Designed to aid practitioners of medicine and surgery, it is concise without being incomplete, lucid without being oversimplified. There are schedules for oral and parenteral use of the sulfonamides. The clinical pharmacology of the sulfonamides, penicillin, streptomycin and tyrothricin is briefly discussed. There follows discussions of the etiology, specific antibiotic therapy and auxiliary therapy and special comments on a long list of diseases, arranged alphabetically. The book is a good up to date summary of a constantly changing field of therapy.

PRINCIPLES OF HEMATOLOGY. By *Russell L. Haden,* M.A., M.D., Chief of the Medical Division of the Cleveland Clinic, Cleveland, Ohio; formerly Professor of Experimental Medicine in the University of Kansas School of Medicine, Kansas City, Kansas. Third edition, thoroughly revised. Pp. 366 with 106 illustrative cases, and 167 illustrations including 173 original photomicrographs and 95 original charts and drawings. Cloth. Price, $5.00. Lea & Febiger, Washington Square, Philadelphia 6, 1946.

The third edition of this well and favorably known work on hematology is a concise exceedingly well prepared and profusely illustrated volume. The author regards the disorders of the blood as disturbances in the physiology of the blood constituents rather than true diseases of the blood. All the blood disorders may be regarded as disturbances in the formation, the circulation, or the destruction of the cells of the blood.

A new seven page section on bone marrow puncture and study has been added to this edition. There are also additional illustrative case reports. The author has purposely omitted discussion of the Rh factor in order to maintain the simple fundamental nature of the book. The first six chapters are devoted to the formation, morphology and physiology of the cellular elements of the blood. Chapter seven is a 47 page description of the technic of blood cell counting, hemoglobin determination, calculation of the various indices, bone marrow puncture and certain other special tests. Three chapters are devoted to the mechanisms of anemia and polycythemia, leucocytosis and leukopenia and abnormal bleeding. The remaining chapters present the clinical aspects of hematology and contains numerous illustrative case reports.

This volume can be unreservedly recommended to students and practitioners as a concise, lucid presentation of the disorders of the formation, circulation and destruction of the cellular constituents of the blood.

HANDBOOK OF TREATMENT AND MEDICAL FORMULARY. By *Charles M. Gruber,* Ph.D., M.D., Professor of Pharmacology, Jefferson Medical College, Philadelphia. Fabrikoid. Price, $7.00. Pp. 585. F. A. Davis Co., 1914-16 Cherry St., Philadelphia 3, 1948.

This is an eminently practical volume offering the essence of modern treatment in every day medical practice. It presents causative factors, symptoms and differential diagnosis when indicated. Excellent points of managing the patient, selected prescriptions and even some physical therapeutic measures are offered. Diseases are listed alphabetically and an appendix of 57 pages enumerates the newer as well as standard drugs and other preparations with average doses. References to the original articles on important therapeutic points or prescriptions are freely given; prescriptions are written in both English and Latin and doses are given in both the metric system and the apothecary's. Gruber's book is indeed a miniature, up to date and reliable encyclopedia of modern therapeutics and should find enthusiastic reception by all practicing physicians.

PHYSICAL MEDICINE ABSTRACTS

Clinical Axioms in Physical Medicine. E. M. Smith, and B. A. Strickland, Jr.

South. M. J. 41:844 (Sept.) 1948.

Ten axioms have been presented for and against the varied physical therapeutic measures. They are that the diagnosis of the condition being correct, the physical therapeutic application can be specific; certain results or effects can be expected and determined, and what not to expect may be known. One should advocate physical therapeutic measures as an adjuvant to recovery and not as the main modus operandi. Physiologic action is usually from without to within, easily controlled, maintained, or terminated. These axiomatic observations aid further in replacing empiricism with rationalism in physical medicine. No branch of medicine being an exact science, but rather a scientific art, a constant and diligent search by the physiatrist for lucid, factual data concerning physical agents must be continued.

Boxer's Bursitis. A. Waxman, and H. Geshelm.

California Med. 69:203 (Sept.) 1948.

In a five-year period during which 523 injuries to professional and amateur boxers and wrestlers were treated, traumatic bursitis of the metacarpophalangeal joints of the hand was diagnosed in ten instances. The diagnosis of bursitis was confirmed by aspiration of bloody or gelatinous fluid from the affected bursa. The lesion occurred particularly in Negro pugulists following knuckle injuries. Review of the literature indicates that this is a relatively rare disease. These cases were among 22 knuckle injuries treated during the same period, 12 of the 22 (nine in Caucasians and three in Negroes) having been simple contusions which were completely reduced in a few days of treatment with hot soaks. Conservative treatment in seven of the cases of bursitis, consisting of aspiration of the bursea, hot soaks and adhesive strapping and physical therapy, resulted in clinical cure. In the remaining three the bursal sac was excised and clinical cure followed. Reports of the cases in which the bursal sac was removed are made in detail.

Physical Methods of Treatment in Psychiatry and Their Implications to General Medicine. William Sargant.

North Carolina M. J. 9:367 (Aug.) 1948.

With a few notable exceptions, such as the malaria treatment of general paresis, the possibilities of specific treatments for the psychoses were, until a few years ago, regarded by psychiatry with cautious pessimism. At the same time psychiatrists were perhaps overoptimistic about various forms of psychotherapy for the neuroses. The last ten years have reversed the picture to a considerable extent.

Just before the war electric convulsion therapy, the giving of a series of electrically induced epileptiform convulsions, had been introduced. It was hoped that this might supplant insulin in the treatment of schizophrenia. Published figures and the clinical observations of those who have been able to use and compare both methods over some years now, show that this is not the case. Electroshock treatment is a useful supplement to insulin in schizophrenia and the best results are obtained if these two treatments are combined when patients do not respond to either individually.

Aftercare of the Aged Sick. E. N. Thomson, and M. Curran.

Lancet 6520:241 (Aug. 14) 1948.

In 1946, among the elderly people outside of a hospital, only 51 out of 1001 were willing to go to a home for the aged, even though the conditions were described in rosy colors; yet 301 were willing to go to hospital. On this occasion only 10 out of 318 would have gone to such a home, the remaining 308 giving a definite refusal. The reason is not far to seek. When hospital admission is suggested, the patients know that they will probably be discharged in a few weeks after good nursing, a rest and general care, apart from any medical or surgical treatment required. They know that when they leave a hospital they will be returned to their own home, their own corner of the world, which has been kept open for them by relations or by the local authoriy. But they feel that there is a finality about going to a home for the aged. They will never return to their own fireside and if they leave the home they will have no place to go to, because their houses will have been given to others.

Many of those admitted to a hospital require only general medical or nursing care, impracticable in their home surroundings but possible in a convalescent home; they do not need examination or treatment by a specialist, but could be treated by a general practitioner, if their social condition had been better. They would be pleased to go to such a recovery home, even for several months, because they know they would eventually come back to their own house. The authors suggest that, when planning for old people's welfare, local authorities should consider the provision of such homes, with nursing care and with medical attention readily available. This would help to relieve some of the pressure on hospital beds in favor of those who require skilled treatment and

would diminish the number of elderly people entering public assistance institutions.

The nursing in these recovery homes does not call for a full staff of trained nurses; a few such skilled people would be necessary, but most of the staff could quite well be assistant nurses.

Thermionic Valve Stimulators; Their Value and Limitations. Anthony E. Ritchie.

Brit. J. Phys. Med. 11:101 (July) 1948.

The increased incidence of nerve injuries during World War II, together with advances in electrical technic, has led to a considerable bulk of physiologic, electrical and clinical literature dealing with precision stimulation of nerve and muscle. The term "electronic" widely used to describe stimulators employing thermionic value circuits, is to be deplored, for any electrical instrument, with or without valves, is dependent on electron movement and control. The modern valve stimulators can produce electrical shocks or an accuracy and type which older devices dependent on mechanical interruptors could not; at the same time their reliability and life are comparable with those of a household radio set. There is no doubt that quantitative excitation of nerve and muscle can provide more information than could the classical methods, at the expense of a certain loss of simplicity in conception; this is more than made good by its convenience and comfort to both the operator and patient.

The primary purpose of the article is to review and attempt to assess the merits and limitations of thermionic valve stimulators in practical use.

Poliomyelitis in Children: A Clinical Study. Clifford K. Kobayashi, and Joseph L. Kehoe.

J. Iowa M. Soc. 38:402 (Sept. 15) 1948.

This paper reports the clinical experiences with poliomyelitis in children who were seen in the Department of Pediatrics of the State University of Iowa during a ten-year period from Jan. 1, 1937, through Dec. 31, 1947.

Treatment during the acute phase was by various means. Roughly, the entire group was divided into two sub-groups; those treated with and those not treated with Kenny packs. Those treated with packs received the Kelly technic with a few modifications. A total of 194 children received the modified Kenny and a total of 184 children received the non-Kelly regimen. It is interesting to note that more children treated with packs had residual muscle weakness than those who were not treated with packs. An erroneous conclusion can be drawn and should be guarded against because of the relatively shorter follow-up period for those who received the modified Kenny regimen.

Between 30 and 40 per cent of the children who had evidence of muscle weakness at the time of admission eventually recovered without residuals regardless of how they were treated. Hot packs were not curative, and were not necessarily superior nor inferior to other methods. It was a clinical impression that packs, more than any other measure, afforded comfort to the children, especially those with muscle tightness or spasm associated with pain. Furthermore, the children received greater attention during treatment with packs than with other measures.

Tensile Strength of Human Nerves. An Experimental Physical and Histologic Study. C. T. Liu; C. E. Benda, and F. H. Lewey.

Arch. Neurol. & Psychiat. 59:322 (March) 1948.

The necessity of bridging large gaps in injuries to peripheral nerves by means of end to end sutures made it important to obtain reliable data concerning the tensile strength of human peripheral nerves. Experiments in this direction were carried out on human peroneal, ulnar, sciatic and tibial nerves removed at autopsy and stretched with the help of a commercial tensiometer under well controlled conditions. The apparatus and its applications are described. The elongation of nerves under varying degrees of tension was measured.

Stress-strain curves of the data so obtained showed that the point where the curves became discontinuous was located at a mean elongation of 4.2 per cent for ulnar and peroneal nerves. Histologic examination of 22 overstretched nerves corroborated these observations. Tears of all myelinated nerve fibers at one point were observed with a stretch of 10 per cent. Individual fasciculi ruptured at different points with a stretch of 6 per cent, and minimal tears of single nerve fibers or small groups at different points of the stretched nerve may occur with an extension as low as 4.7 per cent. The histologic picture of damaged myelin sheaths produced by means of compressing and overstretching an excised nerve appeared almost identical to that of an intravital pathologic process. A human nerve must not be stretched more than about 6 per cent of its mobilized length. The remaining 14 per cent needed to bridge a gap of 13.5 cm. in the ulnar nerve is probably gained by straightening.

Treatment of Asphyxia by Firemen. O. E. Spurgeon.

J. Indiana M. A. 41:307 (March) 1948.

Spurgeon says that for many years fire departments have had some sort of apparatus to resuscitate persons who have drowned or who have become asphyxiated with gas or who have ceased to breathe for some other reason. In almost all cases firemen arrive on the scene before the physician, and often long enough before to make the difference between success and failure. The apparatus called inhalator delivers oxygen and carbon dioxide under moderate controlled pressure and may be used in conjunction with artificial respiration by the manual method. The respirator delivers carbon dioxide and oxygen under pressure. This apparatus can be regulated to produce inflation of the lungs and then suction, to remove the air from the lungs. This apparatus performs arti-

ficial respiration mechanically. The author is of the opinion that fire departments should be encouraged to respond to cases of asphyxia and that physicians should give the department cooperation, but unless a physician also responds to the call and cooperates with the firemen a patient will occasionally be lost who could have been saved. In certain cases more than artificial respiration is required if a life is to be saved. It is important to determine the causes of the cessation of respiration, but it is unwise to send a patient to the hospital whose respiration has ceased. Artificial respiration should be given immediately.

Rapid Treatment of Early Syphilis: Progress Report. J. R. Heller, Jr.; R. W. Bowman, and Eleanor V. Price.

J. Ven. Dis. Inform. 29:103 (April) 1948.

This report by Heller and his associates is the ninth in a continuing series of progress reports evaluating the effectiveness of various forms of rapid therapy for early syphilis. Treatment and follow-up data have been furnished by fifty state and locally sponsored rapid treatment centers. This report is limited to schedules utilizing penicillin, either alone or combined with oxophenarsine hydrochloride, with oxophenarsine and a bismuth compound or with fever therapy. The schedule with the lowest cumulative retreatment rate (4.3 per cent) and the highest rate of seronegativity (80.8 per cent) is the schedule employing 3,400,000 units of aqueous penicillin given in injections of 40,000 units at two hour intervals. The relative safety of schedules that use penicillin alone as compared with schedules that combine oxophenarsine hydrochloride with penicillin is shown by the following facts. There were no fatalities when penicillin was used without oxophenarsine. The severe reaction rate in 1,000 treated patients was only 6.3 for aqueous penicillin used alone and 3.1 for penicillin in oil and beeswax. A total of 16 treatment deaths occurred when oxophenarsine hydrochloride was used with penicillin; the rate was 1 death for every 5,900 patients treated with oxophenarsine combined with aqueous penicillin and 1 death for every 30,300 patients treated with oxophenarsine combined with penicillinin oil-beeswax. Hemorrhagic encephalitis was the principal cause of death in methods utilizing oxophenarsine combined with penicillin.

Ultraviolet Blood Radiation Therapy. G. P. Miley, and J. Christensen.

Rev. Gastroenterol. 15:271 (April) 1948.

Miley and Christensen treated 79 consecutive patients who had acute virus or virus-like infections with ultraviolet radiation of the blood. The technic of this therapy consists of withdrawing approximately 3 per cent of a patient's total blood volume, citrating the withdrawn blood and immediately passing the citrated blood through a Knott hemoirradiator, which exposes the blood safely and efficiently to high intensity ultraviolet rays. The irradiated blood is then returned to the patient's venous circulation. All the 43 patient's with early and of the 27 with moderately advanced infection rapidly recovered, and 8 of 9 of the apparently moribund ones. The subsidence of toxic symptoms in patients with poliomyelitis of bulbospinal and spinal type, with primary atypical or "virus" pneumonia, with mumps and with acute herpes, occurred with striking regularity within twenty-four to seventy-two hours. No ill effects were noted. The mechanism by which this method acts is not definitely known, but it seems highly probable that the resistance of the host is raised rapidly and efficiently by a direct stimulating and energizing effect after the intravenous induction of ultraviolet energy. It is strongly suggested that ultraviolet irradiation of the blood may be observed to be the ideal method of controlling acute virus or virus-like infections safely and efficiently.

Irradiated Blood. Thomas P. Butcher.

To the Editor:—What is the status of ultraviolet irradiation of the blood and the "Knott hemoirradiator"? Is it regarded as of clinical value?

Answer.—There is no conclusive evidence that irradiation of the blood with ultraviolet light has merit. The studies in this field have suffered from the lack of adequate controls. The greatest possible usefulness of ultraviolet light in relation to blood lies in the radiation of pooled plasma to inactivate the virus of homologous serum hepatitis. However, the proper technic for such disinfection of plasma has not as yet been perfected.—[J. A. M. A. 138:255 (Sept. 18) 1948.]

Scottish Experiments in Social Medicine. An Experiment in Rehabilitation. Frank G. Dickinson.

J. A. M. A. 138:450 (Oct. 9) 1948.

In January, 1943, the department instituted a scheme to return the sick and injured to active employment. A fitness center for disabled miners was opened; other workers were later admitted. The program consisted of activity by the patient under the direction of a physician. Average length of stay in the center is from fifty to eighty days; the discharged patient is checked by follow-ups after two and six months. Results up to June, 1947 show that of 1,900 miners treated, 63 per cent were able to continue their former work, 19 per cent were fit for light work, 5 per cent were fit for alternative employment and only 1 per cent were unfit at the end of the course. Of 270 other workers treated, 69 per cent returned to their former work and less than 1 per cent remained unfit for employment. Rehabilitation methods cannot cover deficiencies in surgical or medical treatment, and must be varied with the needs of the patient. Moreover, the study indicates the rehabilitative value of returning the patient to work for which he is fit as soon as possible.

End

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SUBJECT INDEX

This is an index to all the reading matter in the ARCHIVES, except the Medical News Department.

The letters used to explain in which department the matter indexed appears are as follows: "E," Editorial; "C," Correspondence; "ab," abstracts; the star (*) indicates an original article in the ARCHIVES.

This is a subject index and one should, therefore, look for the subject word, with the following exceptions: "Book Reviews" and "Deaths," are indexed under these titles at the end of the letters "B" and "D." The name of the author, in brackets, follows the subject entry.

For author index see page 803.

C

D

DEATHS

E

AUTHOR INDEX

In this Index are the names of the authors which have appeared in the *Archives*. The (*) preceding the page reference indicates that the article appeared in full in the *Archives*, "d," discussion. The "ab" following page references indicates abstract. For subject index see page 796.

INDEX TO PAGES

Of the Archives, According to Monthly Issues—Volume XXIX, January-December, 1948

1— 64	1	January	385—448	7	July
65—128	2	February	449—552	8	August
129—192	3	March	553—616	9	September
193—256	4	April	617—680	10	October
257—320	5	May	681—744	11	November
321—384	6	June	745—808	12	December